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VOL I. No 8. PUBLICATION OFFICE: 411-413 PEARL STREET, NEW YORK CITY. APRIL: 1895.

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CONE PULLEYS AND BELTS, W. L. CHENEY.

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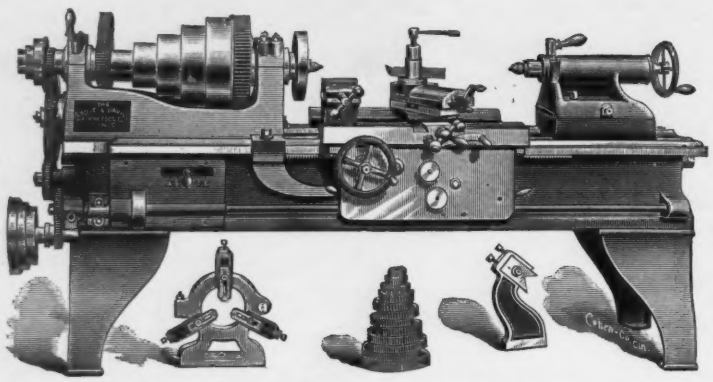

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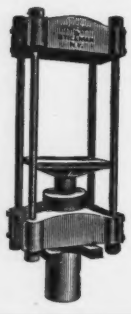

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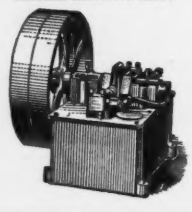

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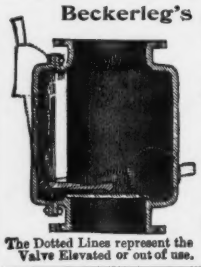

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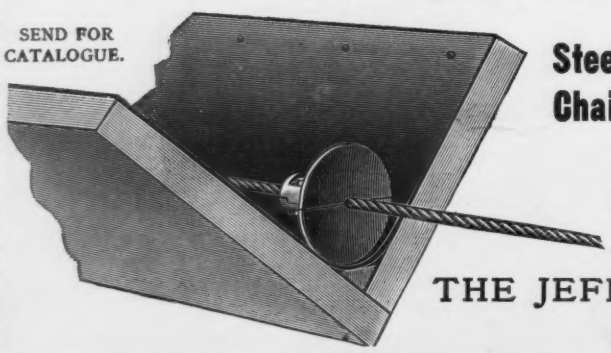

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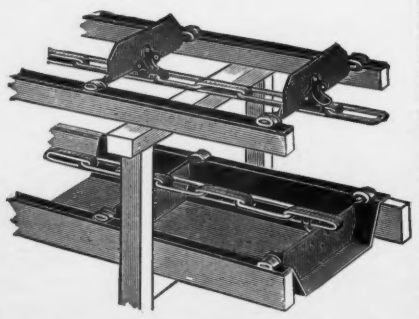

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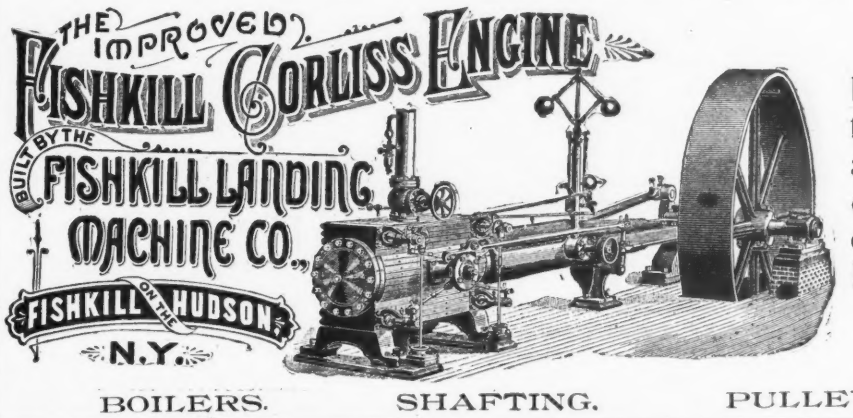

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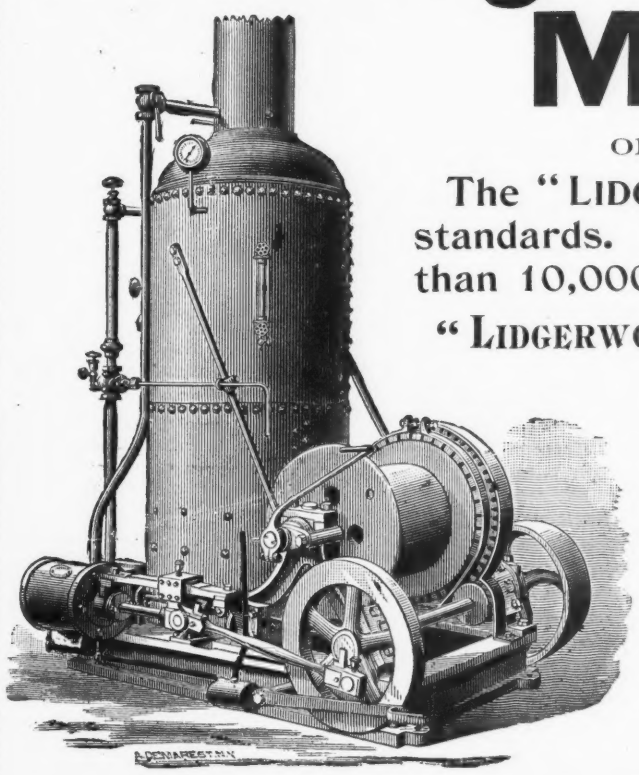

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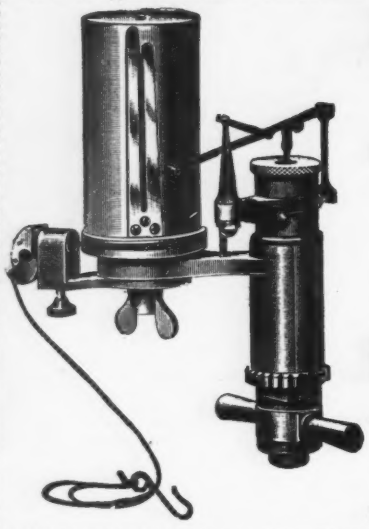

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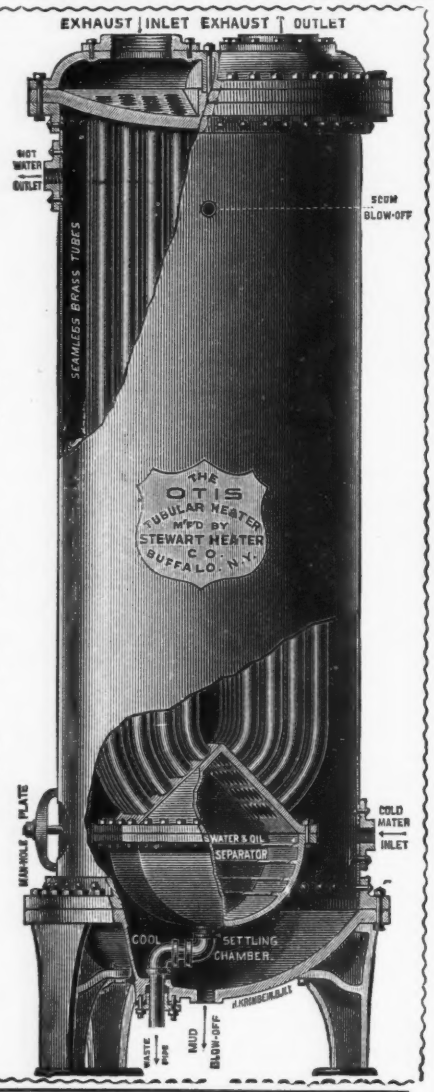

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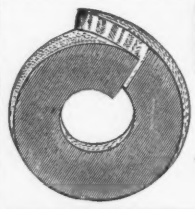

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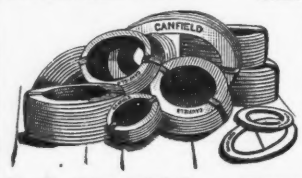

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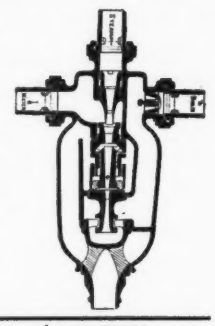

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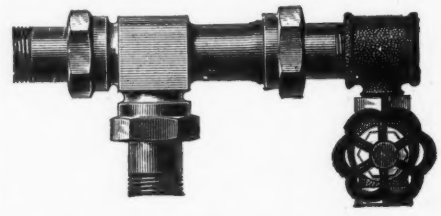

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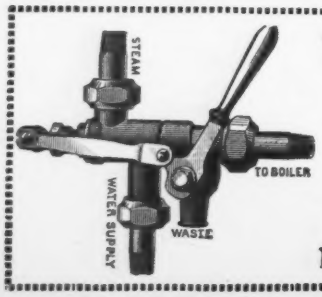

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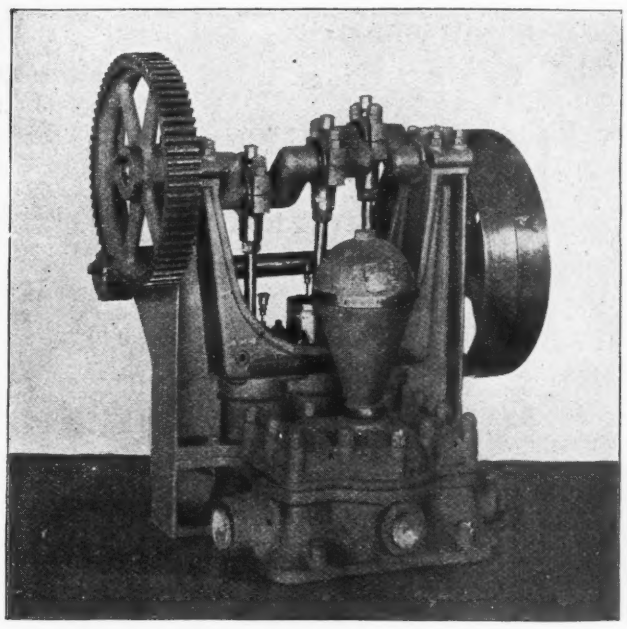

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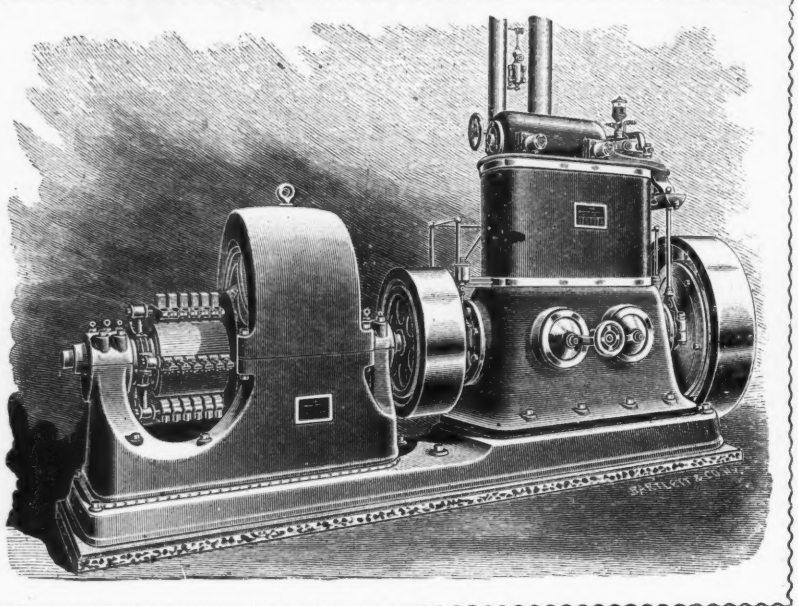

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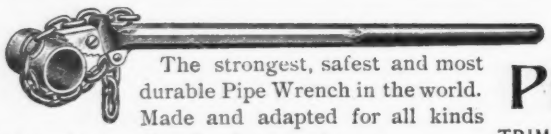

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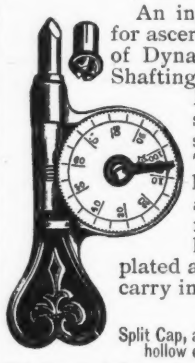

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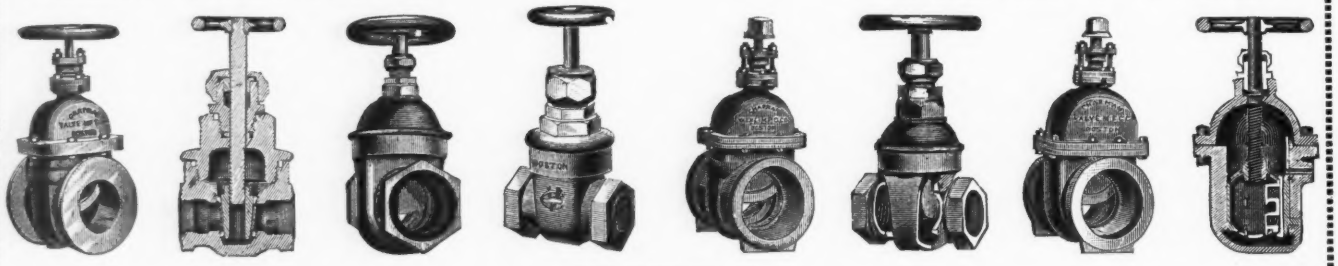

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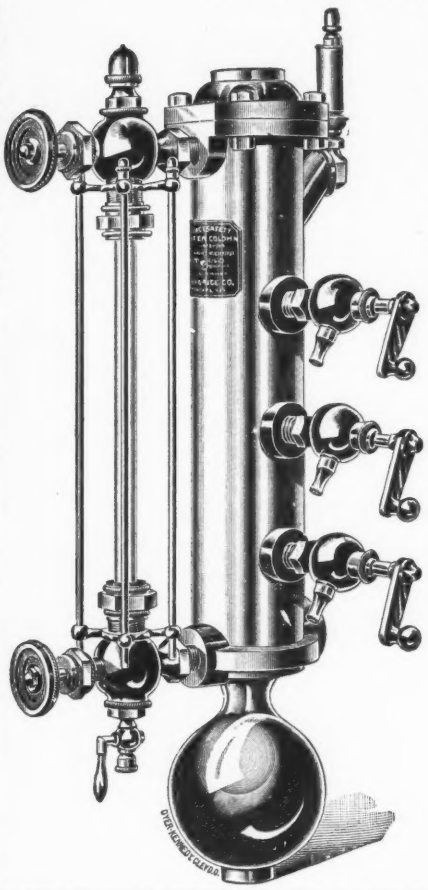

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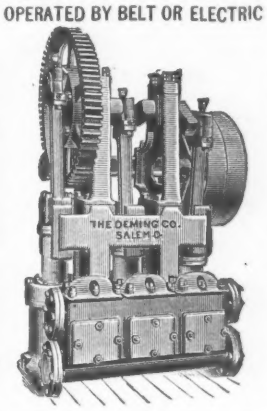

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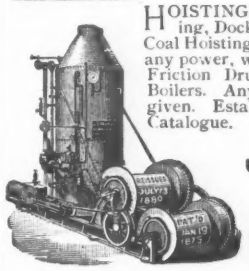

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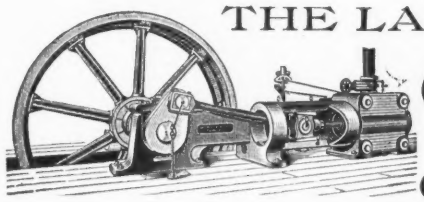

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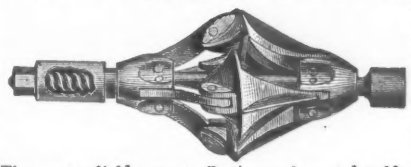

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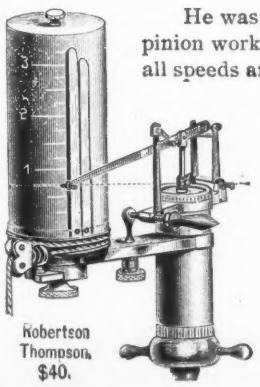

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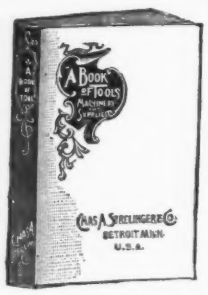

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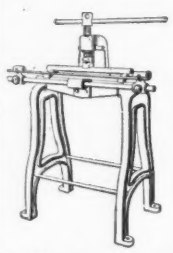

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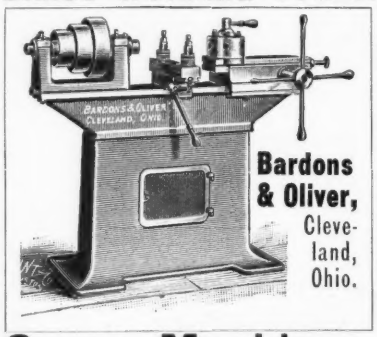

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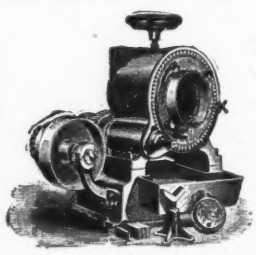

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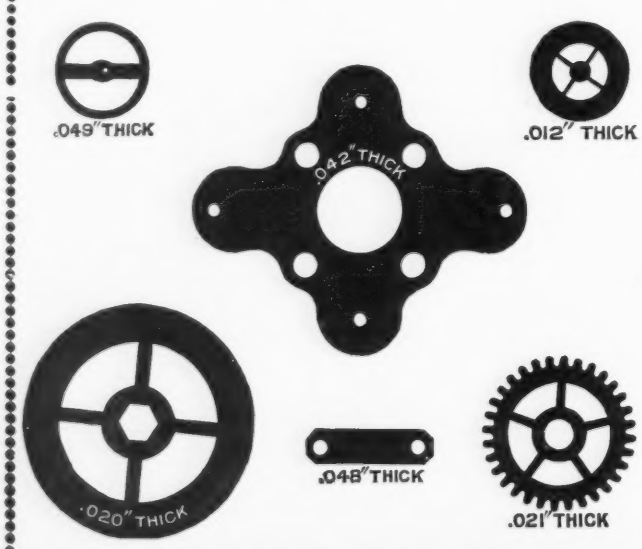

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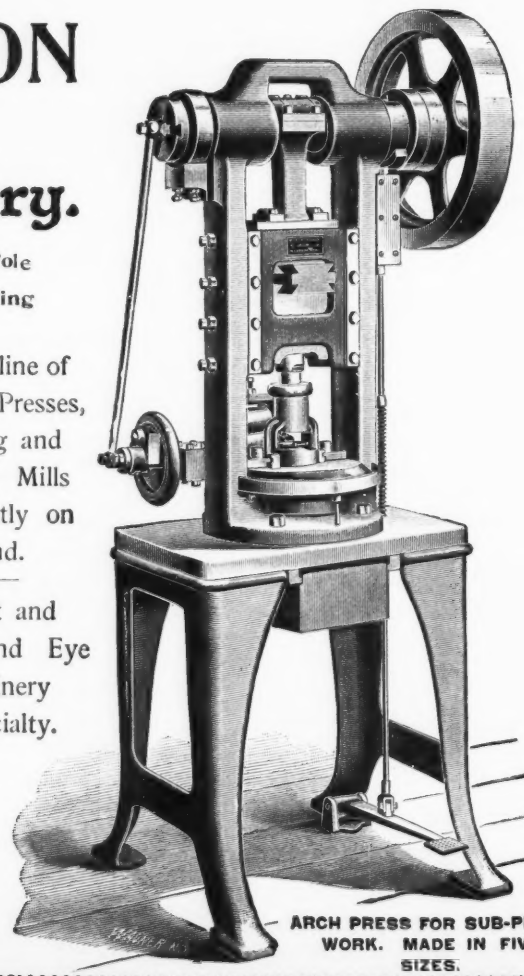

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MACHINERY.

VOL. 1. April, 1895. No. 8.

MACHINE-TOOL NOMENCLATURE.

OBERLIN SMITH.

THE majority of machinists, and also their employers, would probably resent a gentle hint that they didn't exactly know what tools they were using, and yet when one comes to think of it, do we not find (as we do in too many other branches of scientific nomenclature) that some definite dictionary-making is badly needed for our machine shops, in the vocabulary of which two or more words often mean the same thing, and several different things frequently enjoy but one name in common?

A machine tool, as the term is generally understood, is a machine whose function it is to carry and guide, with certain accurate, predetermined relative motions, a piece of cold metal called the "work" against a cutting instrument called the "tool." I purposely say *relative* motions, because either of these individualities (the cuttee and the cutter, as the case may be termed) may be stationary in relation to the floor of the shop and the frame of the machine, and this in regard to all or a part of the several lines of motion involved. For the purposes of this article I limit myself to metal cutting apparatus, although numerous members of the prolific family of devices known commercially as wood-working machines are built upon the same principles as are the machine tools proper, and perform similar functions; only upon pieces of wood instead of metal. A notable instance of this is seen in the best modern pattern-maker's lathes, which are almost exactly like a machinist's so-called engine lathe except in being lighter for a given capacity. Looking further, we find that the respective types of end and side-cutting rotary wood-planers, and also circular saws, are nothing more than modified milling machines, while a mortising machine and the machine shop slotter are closely analagous.

Oberlin Smith.

In the definition given I have included such machines as shearing and punching presses, although these are sometimes classed with machine tools and sometimes not. Such classification is correct when they are used as cold-metal cutters, although (except when used for drifting and broaching) their method of cutting is the *shearing* one only. This and the *chiseling*, or wedging apart process, of separating two portions of a piece of matter, are two primal forms of effecting a separation, neither of which is exactly embodied in the *paring, shaving or scraping* process employed in machine tools proper. This "paring," as I will hereinafter term it, is evidently a combination of shearing, which slides the particles of metal past one another; and chiseling, which splits or wedges them apart. It has the peculiarity, however, that instead of cutting a thing into two nearly similar pieces it always takes a little piece away from a big piece, leaving the latter intact and crumbling the former into numerous chips.

Referring again to variations in nomenclature, we find, besides the uncertainty above cited regarding shearers, etc., that these machines are often called merely "tools," while the same name is given to the pound or two of sharp-edged steel that is mounted upon them to do the cutting. Certain forms of lathes are called "boring-mills," or perhaps simply "mills." This name, mill, also sometimes given to the toothed rotary milling-cutter used in a milling-machine, which latter, in its turn, is sometimes called a "miller," though too rarely. In like manner another "tool" is indifferently called a "drilling-machine," a "drill-press" (why press?), and a "drill," the latter name being also rejoiced in by the little rotary cutting tool inserted in its "spindle," or "arbor," or "mandrel," or whatever else it may be termed. Many other instances of like nomenclative foolishness might be cited, and much might be written urging a systematic christening of these interesting machines. Possibly our future reformers may adopt throughout such sensible functional names as those enjoyed by the planers and grinders already in use, adding "turner," "borer," "driller," "miller," etc. Possibly also the machinists operating them will be subclassified as "turnists," "planists," "drillists," etc; and their work will be duly recorded by a golden-haired fairy of a typewritist, upon a yet-to-be invented silent-tongued typewriter, should the world ever be favored with such an immensely desirable instrument.

A *functional* classification of machine tools, geometrically considered, will first dvide them into two general groups—in one, those of the lathe family, and in the other those of the planer family. The first produce surfaces of revolution—as a sphere from a semi-circle, a cone from a triangle, a cylinder from a rectangle, etc. With the lathe proper and its variations may be classed all sorts of boring, drilling and screw-cutting machines,

also some millers and grinders, in the cases where a milling-cutter or grinding-wheel perform respectively the functions of a lathe-tool by being applied to the surface of work which revolves against them. In the second group we may include planers, shapers, slotters, shearers and punchers (if I may yet use these easy names), together with the majority of millers. Obviously these machines all produce surfaces of "slidation" (to coin a word analogous to "revolution") which, in common with their simplest specimen, a plane, consist of parallel straight-line elements. These surfaces may evidently be curved in one direction, as in cylinders, cones, etc., providing this curvature is managed by the feed, while the cutting is done lengthwise in a rectilinear fashion only.

If we attempt a classification by *methods of cutting*, instead of by forms produced, we must put the millers and grinders together in a group by themselves—that is if we consider an emery wheel or a grindstone as but a certain form of milling cutter, which is nearly enough true. All other machine-tools, except perhaps shearers and punchers, would be put in another group, as using in common the single-pointed or edged type of cutting tool. Even the last mentioned machines might by a little stretch of imagination be relegated to this class, as analogous with the ordinary slotter, an upper shear-blade being merely a very wide flat cutting tool, and a punch being a tool of the same kind made to cut all around at once, the chips which are removed being in either case concentrated into a solid lump, so to speak. Of course when such a tool is used for drifting or broaching the analogy is still closer.

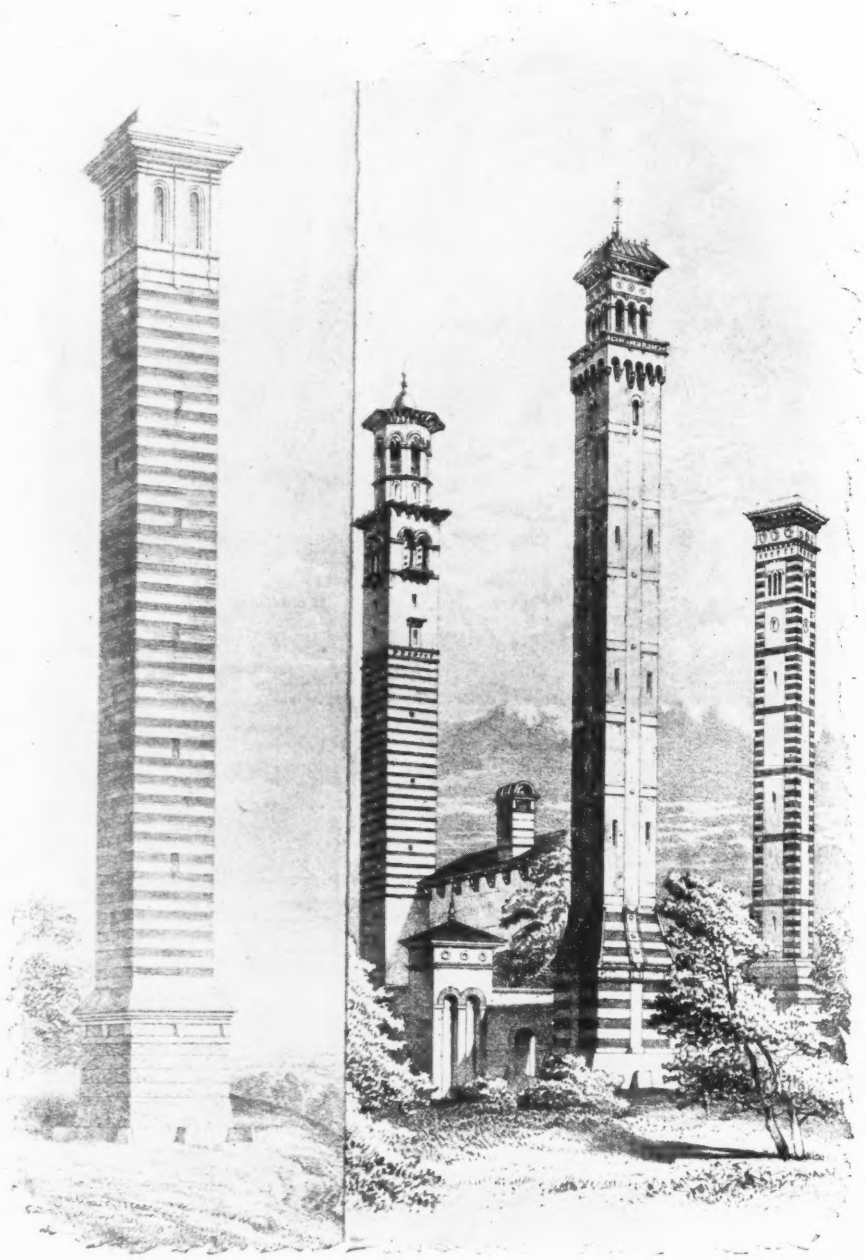
Considering briefly the christening and classification of some of the individual members of the machines in question, we find the use synonymously of the words frame, bed, shears and housing; or of carriage, saddle, slide, bed and table; or of ram, mandrel, gate, head, plunger, slide, slide-bar and bar; or of shaft, mandrel, spindle, arbor and bar; or of cone and cone-pulley; or of cog-wheel, gear-wheel, gear and wheel; or of crank, crank-handle and handle; or of pulley, belt-wheel and wheel; or of key, spline and feather; or of washer, disc, collar, sleeve and tube; or of bolt, tap-bolt, cap-bolt, screw and set-screw, etc., etc., almost *ad infinitum*.

It will be noticed that some of the names above given are common to two or more groups, and that things overlap and intermix generally. I will not, however, in the small space which the editor has kindly allowed me, or in the finite amount of time just now at my disposal, attempt to treat this subject with any degree of thoroughness, nor indeed to more than give the few hints contained in the above paragraphs. These may possibly be of use in exciting interest in an almost neglected subject, and in inducing others to consider whether something cannot be done in the near future to prevent engineering names from being so indefinite and confusing as to frequently cause serious errors and at all times an amount of trouble in speaking and writing them, which should be entirely unnecessary. Some consolation may be found however, in the fact that the making and using of machinery is all the time becoming nearer and nearer an exact science. We, in this generation, may not live to see our ideal of exactitude, but some fellow who is to come after us will, and its a comfort to think that he'll be a blood relation of some of us.

* * *

After all, we depend on the hand and eye to complete the work done on a machine—if we want extreme accuracy.

* * *



HIGH CHIMNEYS.—FIG. 3. RAWLINSON. HIGH CHIMNEYS.—FIG. 4.

HIGH CHIMNEYS

THEIR ADVANTAGES, ECONOMICAL AND SANITARY.

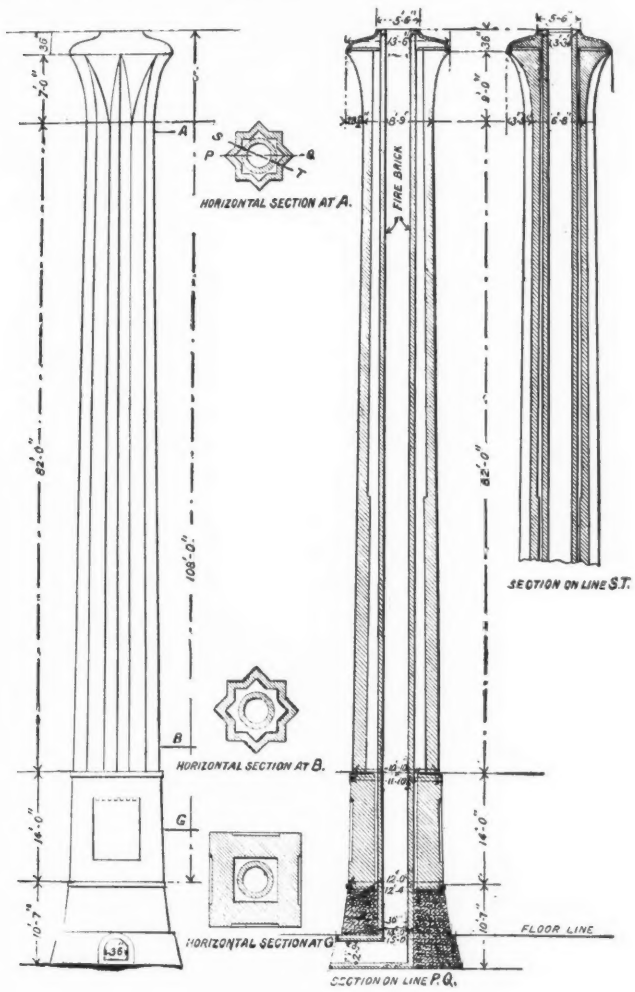
W. Barnet Le Van.

The correct theory of chimney construction to the end of permitting the use of the cheapest quality of coal, while at the same time effecting its complete combustion, not fully understood by many of even the most experienced scientists; or, if understood theoretically, the theory is departed from, or ignored in practice. The economic requirements of the present demand the employment of low grade fuel in our large manufacturing and industrial establishments, but to meet this demand, and justify the use of such low-priced fuel, it is obvious that the economy realized in its purchase must be maintained in its consumption.

To realize this, high chimneys are requisite. When a number of boilers are connected to one chimney, the area of the draft chamber is not required to be so large as that of the sum of several chimneys used for single boilers, since the friction becomes reduced, and the draft is steadier when several boilers are fired successively, and a higher temperature is maintained.

Engineers usually consider that the larger the area of the chimney the better the draft, but this is not the case with high chimneys, since the gases can cool down too rapidly in one of large sectional area. It has, in fact, been found that when a chimney is very large compared with the number of boilers connected with it, or for the quantity of coal burnt, as in the case of a chimney built and adapted for the addition of boilers from time to time, the draft is improved and a higher temperature maintained as the additional boilers are subsequently connected to it.

A chimney suitable for wood, bituminous, or lump anthracite coal would not burn to an advantage the cheap coals now so universally used, such as "pea," "buckwheat," "rice," "barley," "slack" and "culm," unless designed so as to be especially adapted to the latter kinds of fuel. Hence it is well to err on the safe side by building high chimneys of less cross-section, as an excess of draft can be easily regulated. For economy the temperature of the chimney is limited, especially for the cheap fuels



HIGH CHIMNEYS.—FIG. 1.

The section of this chimney is that of an eight-pointed star, see cross-sections in cut. The chimney-cap or chapter is of cast iron made in sections and bolted together. The inside shaft is independent of the outside shaft. BROWN.

now used; therefore the temperature should be kept below 450 degrees. The efficiency of chimneys is difficult to analyze, as the elements are very variable, chimneys often doing better on a calm rainy day than on a windy day.

The influence of external temperature, and of the barometric pressure on the rate of combustion, cannot well be estimated. An increased density of the external air favors combustion by increasing the draft, and also because a less volume of cooler air is necessary to burn one pound of combustible. The draft of chimneys is thus rendered more active in winter than in summer. The influence of the moisture in the atmosphere is often important. In proportion as the moisture in the air increases, the fire slackens, especially with a feeble pressure. A dry, cold air, with high barometer, is therefore more favorable to combustion.

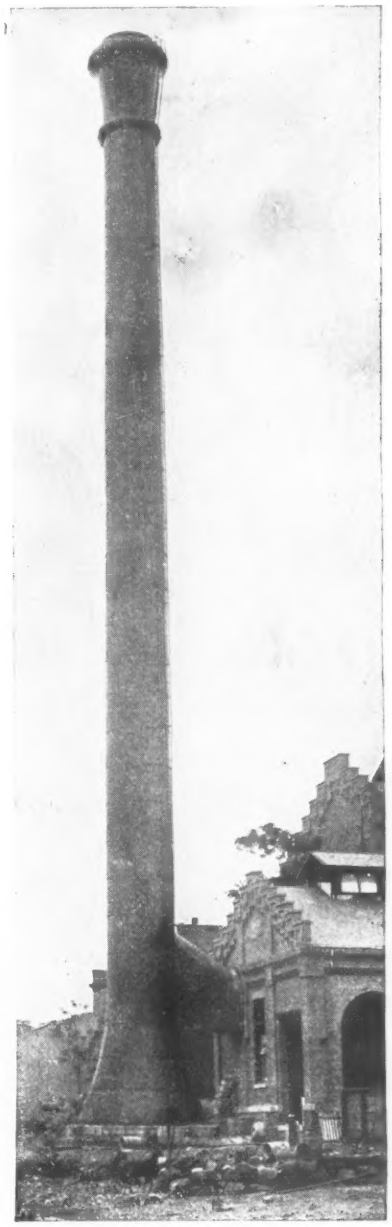
In order that no loss shall occur, it is necessary that the heated gases should always enter the chimney with the least practical temperature. Upon the velocity of the draft depends the proper thickness of coal upon the grate; for if the draft be very strong, and the fire thin, a great deal of unconsumed oxygen will escape up through the fire, and a needless cooling of the contents of the flues will be occasioned; whereas, if the fire be thick and the draft sluggish, much useful effect of the coal wll be lost by the formation of carbonic oxide (C O) in place of carbonic acid ($C O_2$).

In building a chimney an excess of height, as already mentioned, should be chosen, since the draft, if too strong, can be regulated by a damper. In all cases in which the draft is produced by simple "chimney draft," the chimney performs the function of a machine, and its dimensions, height and cross-section taken in connection with the area of the fire-grate, and the surface of the fuel exposed to the action of the air, are the principal elements on which not only complete or perfect combustion, but the quantity of fuel burned in a given time depend. The determination of the proper proportions between the heating and the fire-grate surface depends on the initial temperature of the gases, and as the initial temperature varies with the rate of combustion, or the height of the chimney, this indirectly enters into the consideration of its proportions. The efficiency of high iron or steel chimneys over that of brick chimneys of the same area of cross-section is no doubt due to the leakage of air through the porous brick-work of the latter; the factor of radiation of iron chimneys does not count, as it hardly has time to act because of the velocity of ascentional current of heated air and other gases in the chimney, which in some cases reaches fifty (50) miles an hour.

In the last few years there has been a tendency to go back to the use of artificial draft, induced or forced, by a fan or blower, the main plea being that by the use of an "economizer" in the chimney flue, the boiler would be more economical. This no doubt is true where inferior boilers are used. The adoption of a first-class boiler properly set in brick-work connected to a high chimney, renders the use of an *economizer unnecessary*. The cost of fans or blowers, and the wear and tear of them and the boiler, far exceeds the extra cost of a high and properly constructed chimney.

Large power stations in cities with low chimneys discharge their noxious gases and unburnt carbon in the lower strata of air currents, and these are wafted into dwellings to the detriment of health and cleanliness, especially when bituminous and cheap anthracite coals are used, as is the case of large power plants of modern times.

From a sanitary point of view also, a high chimney is desirable. The city of Carlisle, England, has its sewers ventilated by about thirty chimneys belonging to the different factories. One of these chimneys is three hundred (300) feet high, having an air velocity through it of fifty (50) miles per hour, the air pressure at its base being capable of sustaining a column of water one and one-quarter (1¼) inches in height. The ventilation caused by this chimney is perceptible for a radius of twelve hundred (1200) feet—equal to an area of over one hundred and three (103) acres.



A MODERN STEEL PLATE CHIMNEY.—FIG. 2.
88 inches in diameter by 150 feet high.—GORDON.

From the above (Fig. 2) there will be seen the great advantages to be derived from the use of high chimneys, especially in our large cities, such as Philadelphia and New York. The legislative department of large cities should pass ordinances encouraging the erection of high chimneys by agreeing to pay part of

the expense when chimneys are proposed to be erected, say, to a height of two hundred and fifty (250) feet, or over. In such cases the city of course should reserve the right to connect the sewers to such chimneys for the purposes of ventilation. By so doing the sanitary condition of the city would be greatly improved at a very slight cost, and the power plant could use the cheapest fuel obtainable. Both the community and the manufacturer accordingly being the gainer.

Theoretically the best form or shape of the cross-section of a chimney is circular, and for iron no doubt it is the cheapest, but experiments in conveying both water and air have shown that square flumes for water and square brick chimneys gave better results than did circular conduits of equivalent area. The above experiments were made by the late John William Nystrom and the writer, in 1880, and the explanation arrived at was that gases and water assume a circular or whirling motion, causing a layer of stationary gas on gas or water on water was less than that of the enveloping material, which only acted on a narrow line at four points in a square chimney, the resultant friction was less than that in a round chimney, which is supposed to be reduced in diameter at least four (4) inches by a layer of gas stationary, of two (2) inches around the envelope (see William Kent's paper, page 81, Transactions of the American Society of Mechanical Engines, 1884), but under any circumstances the difference is only about 2 per cent.

Chimneys of large area constructed of iron (see Fig. 2), as stated above, are the cheapest to build; if built of brick they should be square inside and round on the outside, as the latter form presents the least surface to the air and the wind resistance is less.

* * *

GAS ENGINES vs. STEAM ENGINES.

A. Bollinckx.*

Within the past few years gas engine builders have entered the field and endeavored to prove the economical advantage of their motors over the steam engine.

We know by Mr. Aimé Witz that poor gas engines have very nearly attained the limit of economy.

It is therefore interesting to examine the superiority of steam engines over gas engines, even without taking into consideration the daily improvements still being made in the former.

We will take for example the 300 H. P. gas engine described in sundry technical papers, the consumption of which amounted to 2.270 cubic meters of poor gas per effective horse power and per hour, and which was running night and day.

Taking as exact that the cost of gas is 1 centime (two-tenths of a cent) per cubic meter (although this price seems very low owing to the fact that the German gas engine builders mention in their catalogs that this gas costs 2 to 4 centimes per cubic meter); we then will establish the cost of operating said gas engine in the following manner:

300 effective H. P., 24 hours × 300 days per year, at 2.270 cubic meters (80.1 cubic feet) gas per H. P. at 1 centime per cubic meter, or 0.0227 francs per H. P. per hour =		
300 H. P. × 24 hours × 300 days × 0.0227.....	49,032.00	francs
Waste for maintenance:		
1.50 francs per 24 hours × 300 days.....	450.00	"
Oil 4.00 francs per 24 hours × 300 days.....	1,200.00	"
Maintenance per year, for a duration of 10 years.	200.00	"
	50,882.00	"

As will be observed I take into account for lubricating the gas engine the same quantity of oil as for the steam engine, and the same for maintenance. I therefore think I have been very generous, for up to the present I have not came across a gas engine that was satisfied with such a small amount of lubrication as the steam engines and that did not exceed it for repairs and maintenance.

I think it rather difficult for gas engines to be content with 2000 francs for repairs in ten years time, say 200 francs a year; and in what state will a gas engine be after that lapse of time?

I will compare the stoker to the gasogene, whose duty is very similar, and likewise the engineers, as the steam engine also requires one. So we obtain the yearly cost detailed above, as 50,882.00 francs. The steam engine of course requires a boiler.

The maintenance of a boiler, according to Messrs. Babcock & Wilcox, costs 25 centimes per horse power per year, and this statement is in accordance with other important boiler makers' reports. We could not therefore take this expenditure into account, as the similar expense for the gas engine will certainly be higher.

However, let us take 50 centimes per H. P. per year. This makes, for the 300 H. P. considered, 150.00 francs.

A good boiler, with a feed-water heater, will easily vaporize 10 kilos (22.05 pounds) of water per kilo (2.205 pounds) of coal, the water being taken at condenser at 30 deg. centigrade (86 deg. Fahr.) Normal coal costs 9.79 francs ($1.95) per ton of 1,000 kilos at the pit and delivered at Brussels at 13.90 francs per 1,000 kilos ($2.78) per ton. We will so arrive at a production of 9 kilos of steam per kilo of rough coal, but, in order to avoid criticism, we will only count on 8½ kilos of steam per kilo of coal, costing 13.90 francs per ton delivered at Brussels. Now, a steam engine of 300 effective horse power means one of 330 indicated H. P. This figure has often been confirmed by the numerous trials made on steam engines in this country. It will be seen in the report on one of our compound condensing engines supplied to the Ld. Co. "La Vesdre," at Verviers. This engine was working at a boiler pressure of 6.2 atm. (91.1 pounds) and consumed 5.460 kilos (12.03 pounds) of steam per H. P. per hour. Say for 330 H. P. and 5.460 kilos = 1,801.80. kilos per hour for 24 hours, 1,801.80×24=43,243.20, and for 300 days of 24 hours = 12,972.960 kilos of steam. Now, since we get 8½ kilos of steam per kilo of coal, this will give us:

$$\frac{12{,}972.960}{8\frac{1}{2}} = 1{,}526.230.$$

kilos of coal at 13.90 francs per 1,000 kilos=21,214.00 francs.

The other expenses of maintenance, waste, oil and repairs, being the same, we have:

STEAM ENGINE.

Steam.....	21,214.60	francs
Maintenance of boiler.....	150.00	"
Waste.....	450.00	"
Oil.....	1,200.00	"
Maintenace of engine.....	200.00	"
	23,214.60	"

GAS ENGINE.

Gas.....	49,032.00	francs
Waste.....	450.00	"
Oil.....	1,200.00	"
Maintenance of engine.....	200.00	"
	50,882.00	"

This comparison is so conclusive as to make further comment unnecessary.

* * *

A CHEAP BUFFING RIG.

A very handy scheme for buffing small articles where you have no regular buffing appliances, is to take an iron arbor of the right size and wrap a piece of emery cloth around it, taking care to have the edge come so as to be forced down by the work rather than be caught by it. Fasten the emery cloth to the arbor by the set screw of the dog and tie a string around the other end to keep it from uncurling, and you will have a small buffing rig which will do lots of work and which is not very expensive. This is especially useful where a small sized wheel is necessary to get into some small round corner of the work, and can be used in a great many shops to advantage. More mechanical ways to fasten the cloth to the arbor (which can be of hard wood as well as metal) can readily be devised and a permanent feature made of this method of buffing, giving a great variety of sizes and grades of emery at slight expense.

* L'Administrateur Delegue Ateliers de Construction, Brussels, Belgium.

CONE PULLEYS AND BELTS.

W. L. CHENEY.

Did you ever try to start a new machine and find the belt would run only in one place on the feed cones, because it was too loose at all other parts of the cones? I have, and on machinery from places where they ought to know better. When a man wants to find out how to fix such a thing as this without cutting and trying, and goes to look the matter up, about all he can find on record is the following:

$$R = \frac{R_1 + R_2}{2} + \frac{(R_1 - R_2)^2}{2\pi C}$$

This is a little discouraging to the average man with overalls on his legs, and possibly a smut spot on his nose, who wants to use that machine right away to get out those pieces that have been ordered for the last two months.

It is perfectly easy to turn any pair of cones, so that the belt will run on any of the steps, first time trying, if you only know how; and in order to get at the thing intelligently, let us analyze the matter a little.

Every one knows that cone pulleys are *usually* made with regular steps: that is, if it is one inch from one step to the next, it is also one inch from the next to *its* next, and so on. The reason being that when the centers of the shafts on which the cones run are a fair distance apart, the belt will pass *very nearly* half way around that part of each cone on which it is running, and the length of the belt will consequently be (near enough for all practical purposes) equal to twice the distance between the shafts, added to *half* the *circumference* of the grade of one of the cones on which it is running, and *half* the *circumference* of the grade of the other cone on which it is running, and as the steps are even, the half circumference of any two grades of each cone will, when added together, produce the same result. For example, if we had two cones, the diameters of the several grades of which were 6, 8, 10 and 12 inches, it is evident that the sum of half the diameters taken anywhere along the cones, as they would be set up for work, would in every case be the same; and if the diameters are the same, it follows that the circumferences must also be the same, and of course that *half* the circumferences must be the same, so that *when the centers of the shafts are a fair distance apart*, the same belt will run equally well anywhere on the cone, because it runs *so near* half way around each grade of the two cones on which it is running, that the slight difference is within the practical limit of the *stretch* of the belt.

But when the shafts are near together, the belt is not elastic enough to make up this difference. Fig. 1 is a sketch of a three step cone, the grades being 4, 18 and 32 inches diameter respectively, each being 14 inches diameter different from the next, and the *step* being therefore *half* of 14 inches, that is, 7 inches in each case. Of course it is not likely that such a cone as this would be made for practical use, but it is well to go to extremes when looking for a principle, and see where we land. Now it is evident that a pair of cones, even if like the sketch, *set up far enough apart*, would still allow the belt to run *very nearly* hal way around each grade of the two cones, and that the length of belt would therefore still be as mentioned above.

But (again taking an extreme case), by reference to Fig. 2, which is intended to represent a belt running from the largest grade of one cone to the smallest grade of the other cone, we see that the belt runs *three quarters* of the way around the large pulley, and only *one* quarter of the way around the small one, the distance between the shafts in this case being 19¾ inches.

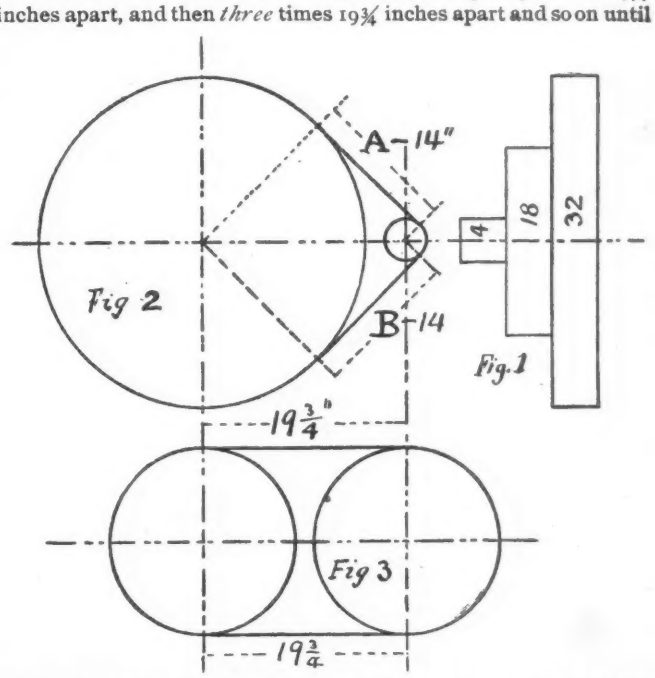
The length of this belt will evidently be equal to three quarters of the distance around the large pulley, added to one quarter the distance around the small pulley, and added to the distances A and B, which we find to be each 14 inches, the *circumference* of a 32 inch diameter pulley is 100½ inches, and the *circumference* of a 4 inch diameter pulley is 12½ inches (near enough for our present purpose); three quarters of 100½ are 75⅜, and one quarter of 12½ is 3⅛; the length of a belt then, to go around a 4 inch and a 32 inch pulley, running at a distance of 19¾ inches apart, is 75⅜ plus 3⅛ plus 14 plus 14; total, 106½ inches.

Now let us take the middle of the cone when the belt is running on two pulleys, both 18 inches diameter (see Fig 3), and of course the same distance apart as before, the circumference of an 18 inch pulley is 56½ inches, and *half* the circumference of *two* 18 inch pulleys is evidently the same as the *whole* circumference of *one* 18 inch pulley; the length of belt in this case will then evidently be 56½ plus 19¾ plus 19¾; total, 96 inches. It is therefore evident that a belt long enough to run on a 4 and 32 inch pulley, 19¾ inches apart, is 10½ inches too long to run on two 18 inch pulleys 19¾ inches apart, and of course it is therefore 10½ inches too long to run on the middle grades of such a cone as we have in consideration.

The thing to do then is to make the middle grades of these cones (or the two 18 inch pulleys) *enough larger* than 18 inches diameter to just take up this 10½ inches of belt, and if this were the only case we had to deal with it would be very easy to settle it by saying that as half the circumference of two 18 inch pulleys is the same as the whole circumference of one 18 inch pulley, we should turn the two 18 inch pulleys enough larger diameter to make an additional circumference of 10½ inches, and as 3⅜ inches is nearly the diameter of a 10½ inch circumference pulley, by turning the middle of both cones 18 plus 3⅜ inches diameter (that is 21⅜ inches diameter), our trouble would be over *in this particular case*. It is easy enough to see, by looking at Fig. 2, that the belt being obliged to go three-quarters of the way around the large pulley, is what makes it so much too long to go around the two middle pulleys, where of course it goes but half way around each.

But of course what we want is some way of calculating the diameters to turn *any* pair of cones, running *any* distance apart.

If we were to draw these same 32 and 4 inch pulleys *twice* 19¾ inches apart, and then *three* times 19¾ inches apart and so on until



we got them far enough apart so that the belt would practically run half way around each, and should calculate the diameter of middle grade of the cone to fit each distance, we would probably formulate a rule that would work for *any* distance apart, *with this particular cone*, but as it is evident that the further apart the cones are to run, the nearer to the *nominal* diameter of 18 inches must the middle of the cones must be turned, so also must it be evident that the *less difference* between the largest and smallest diameter of the cone the *less* must also be the *excess* over *nominal* diameter of the middle of the cones.

Any method then, of calculating such problems must take *both* of these things into consideration. The *nominal* diameter of the middle of *any* cone will be equal to half the sum of the diameters of the largest and smallest part respectively. This is almost self-evident, and no proof of it is necessary in this connection. What we want then is some way to find out *how much larger* than the *nominal* diameter, to turn any cone or cones to fit the conditions under which they are to run, and the formula given at the beginning of this article is the result of a thorough investigation of this subject by Prof. Rankine, and has proved itself to be practically correct in the shop, as well as satisfactory to those mathematicians who are competent to criticise it.

This formula being translated into plain English means that the *radius* of the center of a cone will be equal to the *radius* of the smallest part, added to the *radius* of the largest part, and this sum divided by 2, and added to this the difference in *radius*

between the largest and smallest part, squared (that is, multiplied by itself), and then divided by twice the center distance between the cones multiplied by 3.1416. That is, the first half of the formula gives the *radius* at the center of a cone, when the largest and smallest radius are known, and of course if the middle *radius* is equal to the smallest radius added to the largest *radius* and the sum divided by 2, it follows that the middle *diameter* is equal to half the sum of the *diameters* of the largest and smallest part respectively, as mentioned above.

The second part of the formula allows us to calculate how much larger than this nominal diameter to turn the middle of a cone, no matter what the size or center distance.

Applying this formula to the case of the cones shown in Figs. 1, 2 and 3, we find the *radius* of the middle of the cone to be $10\frac{6}{10}$ inches, or, what is the same thing the *diameter* to be $21\frac{2}{10}$ inches, which, in view of the extreme case in consideration, is very near the first result obtained ($21\frac{3}{8}$) and shows that the formula is perfectly safe in any case likely to occur in practice.

The trouble with this formula (in my opinion) is, first, that it considers pulleys as being of a certain *radius*, instead of a certain *diameter*. I know that a pulley of 12 radius is 24 inches diameter, but it is not *natural* for me to think of a certain *radius* pulley; in consequence of which I get confused when trying to use the formula, and I think this is likely to occur with any practical man. I have therefore reduced this formula to *diameters*, and find it much easier (for me, at least) to work. When so reduced it takes the following form:

$$\text{Diameter at center of cone} = \frac{D+d}{2} + \frac{(D-d)^2}{12\frac{1}{2}\,C}$$

the $12\frac{1}{2}$ being the nearest *in plain and easy figures* to which the quantity 2π in the original formula can be reduced, and I have found this to be plenty near enough in practice; or in other words, the first half of the formula gives the *nominal* diameter of the middle of the cone, which is as before specified, half the sum of the largest and smallest diameters, or as the formula reads, "the large diameter plus the small diameter, and this sum divided by 2."

The *excess*, which is to be added to this nominal diameter, is then (according to the formula) the *difference* between the largest and smallest diameters, squared (multiplied by itself), and this amount divided by $12\frac{1}{2}$ times the center distance.

Applying this simplified formula to the cone which we have been considering, it will be found that the middle diameter is $21\frac{2}{10}$, same as by the original Rankine formula.

If a cone has five steps instead of three, it will be practically correct to add half as much to the nominal diameters of the second and fourth grades as was added to the middle grade, or, if it has four grades, add two-thirds of what is found by the calculation, to the second and third grade (as there is evidently no middle grade). If more than four or five grades, add to each grade according to this same principle.

We have so far been considering two similar cones, but it often happens that one cone is larger than the other. In such case the problem becomes a little longer to work, and the length of belt necessary to go around each pair of steps of the cones must be used to find the diameters; that is, starting with one end of the cone, find the length of belt, and then calculate how much larger or smaller (as the case may be) than the *nominal* diameter it is nesessary to make each grade, in order to make *the same* length of belt run properly.

Prof. Rankine has published a formula for length of belt also, which I have reduced to *diameters*, as follows:

$$\text{Length of belt} = 2\,C + \frac{11\,D+11\,d}{7} + \frac{(D-d)^2}{4\,C}$$

That is, the length of a belt to pass around any two pulleys (and of course a cone is simply a set of pulleys) is the sum of the following quantities: First, twice the center distance of the shafts; second, 11 times the diameter of the larger pulley, plus 11 times the diameter of the smaller pulley and this sum divided by 7*.

*$\frac{22}{7}$ = very nearly 3.1416

Of course, if we should find practically that the middle grades of a cone would not finish large enough to take the assumed length of belt, we would need to turn them as large as they would go, and then turn the others enough smaller to take the same length of belt as the middle grades as turned. Practically, by figuring all the diameters, if found necessary to reduce one of the diameters to make a casting clean, reduce all the other diameters on that cone an equal amount.

This gives the nominal length of belt, or what it would be practically if the center distance was fairly great; for the excess, the last part of the formula, must be used, which is the difference between the diameters of the larger and smaller pulleys (that is, one subtracted from the other), squared, and this result divided by 4 times the center distance.

Having found the length of belt to run on one end of the cones and keeping this for a starter, we can easily then find how much to add or take from the nominal diameter of any other part of the cone to make the same belt run, as explained above. If for instance, we find that the nominal diameters of the next grades that we try bring the length of belt one-half inch shorter than the first calculation, we add enough to one or both diameters to make up one-half inch of *circumference*, which would be about $\frac{5}{32}$ of diameter, and this could all be added to one pulley, or half of it could be added to each pulley, as was practically most convenient, and this would be practically correct.

It will be seen that the figures in the formula are very easy to work with, as to multiply by 11 we need only set the number down twice, one under the other, but of course one place to the left, and add. I have figured a good many cones from these formulas, and have always had perfectly satisfactory results.

* * *

CROSSHEADS AND GUIDES.

JOHN E. SWEET.

As "Whynot," in his "Notes from the Engine Room," has seen fit to make mention of our method of securing piston-rods to

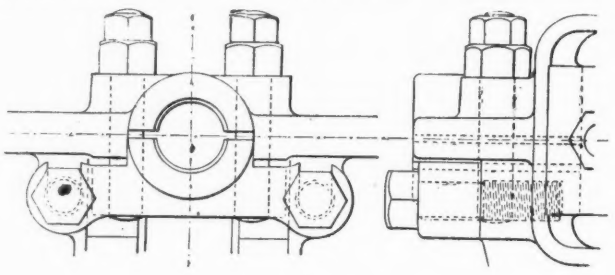


Fig.

crossheads, it is but right to say that I believe the Buckeye Engine Co. were the first to use the grip and the threaded rod, using a split crosshead, which is better for durability than the plan of the half nut, which we have used up to the present time. Our plan of the half nut is very convenient, as it permits of separating the crosshead without removing the cylinder head, in fact it is difficult to find another adjustable attachment, so readily handled as this.

To retain this convenience and gain the good qualities of the

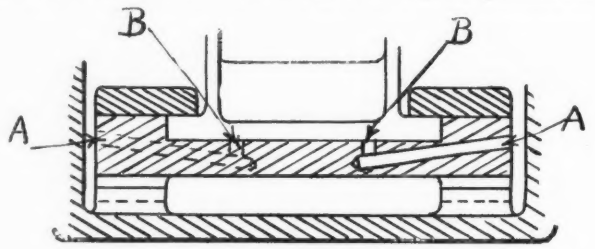


Fig. 2.

Buckeye plan, we have recently adopted the additional feature shown in Fig. 1, to securely hold the half nut from end movement, which the studs, however well fitted, failed to do, owing to small bearing surface This addition has really been called out by the growing increase in steam pressure. The binding bolts are better than any mechanical fit.

Advocating as "Whynot" does, the abandonment of the overrun of the crosshead on the guides, is a very strange suggestion, for the constant tendency of that arrangement is for the crosshead to wear rounding and the slide concave, while we have been for years trying to keep them straight; and while we have cut off the slide so the crosshead overruns fully one-third its length at each end, the tendency is still to wear in a slight degree the same way.

Our practice has been to have the oil float on the drip-water

from the gland, and so do what "Whynot" aims at, and have the crosshead drag the oil back on the slide. On this we have recently made an improvement, by turning to account what proved a failure on the first Straight Line engine ever built.

Showing for example one of our crosshead bottoms and slides in Fig. 2, the slide is set in the water-tight basin and the overflow pipe for the water set so that the top of water and oil will be about $\frac{1}{16}$ inch below the bottom of crosshead. The two holes A A are drilled as shown, and from them two holes B B. The oil floating on the top of the water runs down the holes A A, and the crosshead as it glides over the holes B B pumps up the oil and does the lubricating in the proper manner, the flow of the oil always being in that direction to wash out and away any dirt or grit. With the long crosshead this plan works, whether it would with a short one we do not know. It is not applicable to locomotives, in fact when the work is so much on the upper slide, as is the case with the locomotive, one might question whether the locomotive practice is just applicable to stationary practice, and for that reason.

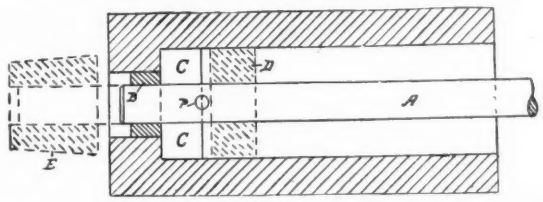
* * *

LATHE AND PLANER HINTS.

"Spike."

BORING EXTRAORDINARY.

The other day I had occasion to increase the size of a hole in a cast iron sleeve twenty-four inches long. The hole was two and one-half inches in diameter, and I made it four and one-half. It was a hurry-up job, so the first question was how to do it quick and right. The sleeve had a flange eighteen inches in diameter at one end, so I had a good chance to chuck it, which I did. Then having a round bar with a cutter-hole near one end, I fitted a collar to the bar ahead of the cutter, with outside diameter to fit hole in sleeve, then strapped the bar to the tool-block and put on a dog to keep the bar from turning around, and having adjusted the cutter for a chip $\frac{5}{8}$ inch deep and a feed of 32 per inch, I proceeded to bore, and did not stop until within one-half inch of the other end. Then I took off the collar and made another to fit the new bore, and finished the first chip through by placing the collar ahead and the cutter projecting as before. I bored the



hole to $4\frac{15}{32}$ inches, leaving enough for a finishing cut, which I took in the same manner as the two previous ones. Time boring the hole from $2\frac{1}{2}$ inches to $4\frac{1}{2}$ inches and 24 inches long, one hour and forty minutes. Time chucking sleeve, getting tools together and making collars, about one hour and a half. Amount of iron removed, 240 cubic inches, or nearly 60 lbs.

I have bored many pulleys in the same manner, starting with a rough cored hole by boring a short distance with a short stiff tool, just for a starter for the collar, letting it follow the cutter clear through. There are objections to this though, as the sand and chips cut out the collars pretty fast.

The cut will help make this clear, as the boring bar A, the cuttert C (shown pinned in), and the collars show its action fully. The dotted outlines to the left show the bush in hollow spindle lathe and the bar in place, as mentioned below.

Another boring bar that beats anything I ever saw for boring small, long holes is arranged as follows: First get your lathe, and get one with a hollow spindle, and if the spindle is made as it should be it will have a good sized hole through it, with a tapering bushing driven into the working end of it to receive the center. Knock out this bushing and make one of soft steel from 1 to 2 inches long to fit the spindle, in place of the center bushing, with a hole of such size to allow the boring bar a close running fit through it. If the bushing is case-hardened it adds greatly to its durability. Then if you have a hole say 1 inch in diameter and 10 inches long to bore, make a bar of round tool steel as hard as you can work (hardness begets stiffness, and stiffness more and better work), about 26 or 28 inches long and $\frac{7}{8}$ inch diameter, with a cutter-hole about $\frac{3}{16}$ by $\frac{1}{2}$ in the middle. Make the cutters to drive through the hole and depend on friction to hold them. Use double or single-ended cutters as is most suitable to the job to be done. Flatten the sides of the bar for a suitable distance at one end to enter the tool-post and adjust one end to the bushing and the other end to the dead center. Secure the work to be bored in a chuck or on a face-plate, as the case requires, and with one end of the bar supported by the spindle and the other by the carriage, and with a double-ended cutter, it is surprising the amount of work that can be done.

If there are a number of pieces to be bored, it pays to have double-ended cutters, but if there are only one or two and have no cutter the right size, you will find that a single-ended cutter will beat any ordinary boring tool, because the bar is supported at both ends.

For chasing a thread through a long hole it takes the lead. Now don't laugh, as I have just been chasing a left-hand 10 thread through a $1\frac{1}{8}$ inch hole 8 inches long, and I was not more than half as long as I would have been with any other means that I know of. But the work must be chucked in such manner as to give a chance to adjust the cutter between the face of the chuck and the work.

Don't think this kind of bar is good only for long holes, because it is equally as good for short ones. The only real drawback in connection with it is the fact that it cannot be used in any but a hollow spindle lathe.

* * *

GFAR TEETH AND STEAM PIPING.

Samuel Webber.

Please correct in your next my formula on page 10 of the March issue, which reads

$$500\,\frac{\text{feet } t^2}{6}$$

and should be

$$500\,\frac{\text{face} \times t^2}{L}$$

or face × square of thickness ÷ by length. Let me also express my concordance with Mr. Fosdick's views of steam piping. It would take a volume to relate the many troubles I have found from inefficient "piping," but I can recall plainly the first snag of the sort I ran across, in 1848. I had been employed as assistant engineer in building some large mills, paying special attention to the wheels, shafting and power, when I was asked to take the position of mechanical superintendent, in the operation of the mills.

When we came to start the dye-house, with which I had nothing to do, we could not get steam.

On examination I found 150 feet of 10 inch pipe supplying a number of dye vats, to which steam was *supposed* to be supplied by a 2 inch pipe, running through a brick wall from the boiler house! It had been fitted up by the "boss" of the repair shop, a good enough machinist, in his way, who told me when I questioned him about the small pipe, that "the pressure in the boilers would blow steam enough through any hole!" and on this basis a good deal of "piping" that I have found seems to have been done. I soon had the 10 inch pipe though the wall to the boilers, with no further trouble.

I also note your answer to a query as to the power which may be safely transmitted by shafting, and your quotation of the formula published by my old friend Mr James B. Francis, of Lowell, of

$$\text{H. P.} = \frac{D^3 \times N}{100}$$

It must be remembered that this formula was for iron, not steel, for which he gave

$$\frac{D^3 \times N}{62.5}$$

which in the instance referred to would give 25.60 H. P. instead of 16. In either case these formulæ allow a factor of safety of 15.58, or are only that portion of the torsional strain required to break the shaft. It must also be borne in mind that these formulæ are for "first movers" only, or cases where there is a heavy transverse strain from gears or belts.

Mr. Francis used for a divisor, in case of line shafting, where there was no heavy transverse strain, only half these figures, or 50 for iron and 31.25 for steel, which in the same case would give the power transmissible as 32 H. P. by an iron shaft, and 51.20 H. P. by a steel one, with a factor of safety of 7.79.

Your correspondent is doubtless right in thinking that he transmits more power daily than the old rule allows for.

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APRIL, 1895.

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We will furnish without charge to readers of MACHINERY, the name and address of any desired manufacturer of machinery, tools, or appliances.

OBTAINING COMMERCIAL ACCURACY.

To the apprentice and to those who study machinery from the outside instead of from actual work in the shop, there appears no reason why absolute accuracy cannot be obtained on any well built machine; why a lathe will not turn exactly round, a planer plane perfectly true, and a boring bar bore holes both round and in line with each other. A long acquaintance with the shop will prove the error of these ideas and show that even with the best of machines, jigs or fixtures in use in machine work to-day, the inaccuracies are often much greater than the best practice permits, which necessitates the employment of skilled hand labor to secure the accuracy desired.

Many costly disappointments might have been avoided had it been recognized that even the highest commercial accuracy cannot be obtained by depending solely on a machine or its fixtures as ordinarily made, but that the work must be finished by skilled labor, the amount varying with the accuracy of the machine used. Not that jigs are useless or that all machines require to have their work finished by hand, for where the margin for inaccuracy is sufficient the work is ready for use as it comes from the machines. But for lathe or milling machine spindle bearings, or other work where the accuracy of the tools' product depends on alignment, both when new and after the inevitable wear from use, there is not a high-class tool that we know of which is not finished by skilled hand work.

We recently saw a massive tool, designed and built especially for boring the boxes of lathes and milling machines, which was probably as accurate as any tool in constant use can be, and yet every box is afterward scraped to a bearing with its own spindle in order to insure the accuracy required. The economy of building this special machine may be questioned on the ground that hand work is required as with an ordinary boring bar, but when the amount of hand work is reduced enough to pay for the machine, taking into account the increased production by its use, it is an economical investment. Knowing that for the present at least, we cannot dispense with hand work where extreme accuracy is required, we should design our work, our machines and our tools so as to reduce the variations to the lowest limits, thus reducing the cost of hand labor as much as possible. And it will be well to remember in designing such tools, that so long as absolute accuracy cannot be obtained, we must carefully consider all the features tending to cause variations, such as spring of work or cutter, and wear of bushings or tools, and find practical remedies for them.

* * *

WE have so many requests for back numbers that we will gladly pay full price for any issue previous to February, which we may receive. Mark your name on the wrapper.

* * *

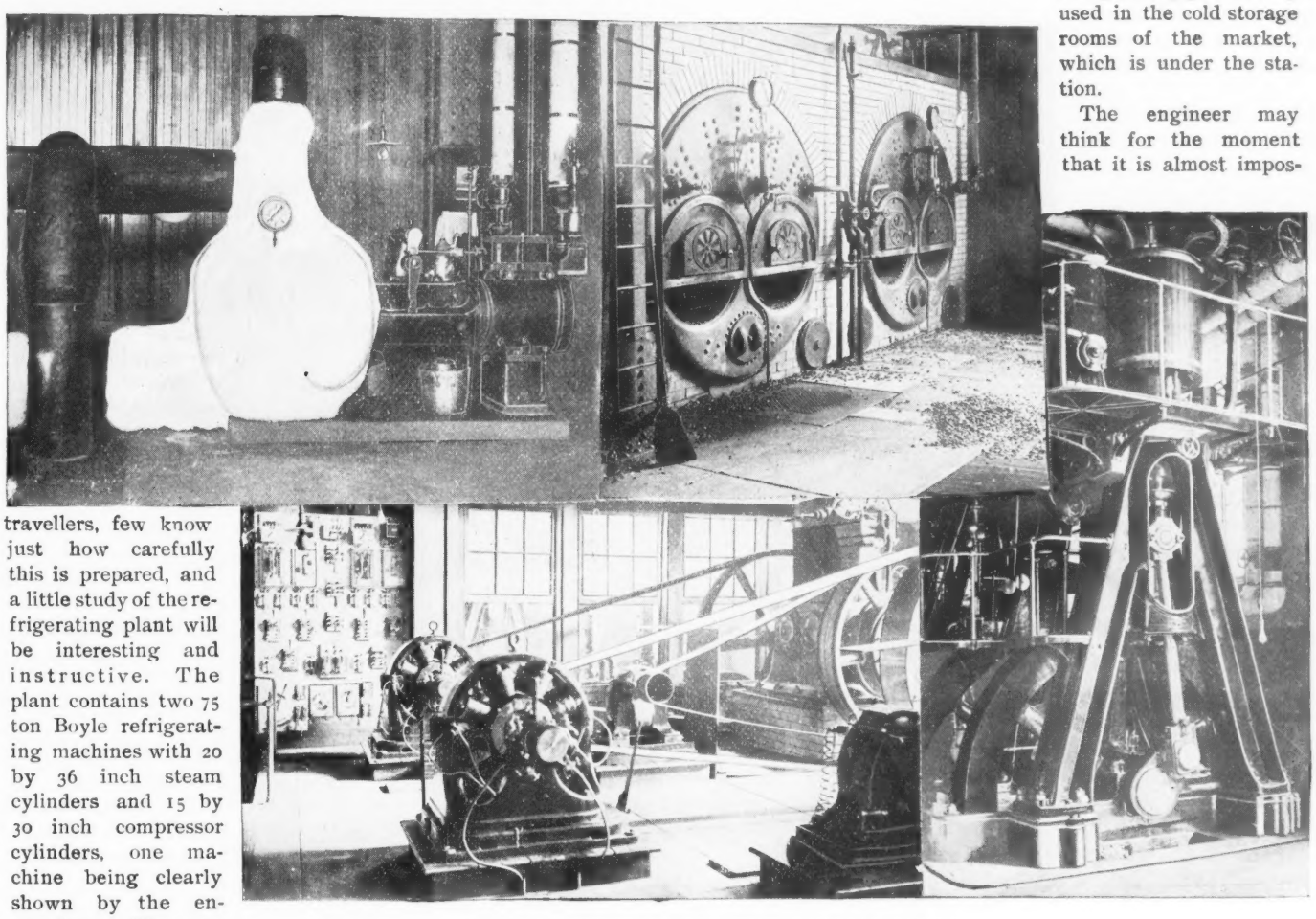
STEAM ENGINE ECONOMY.

The article by M. Bollinckx in this issue, which certainly seems to be a fair comparison in this case at least, shows a decided advantage in favor of the steam engine for this amount of power. The steam consumption given of 12.03 pounds per horse power per hour is much lower than anything in this country for a compound engine with only 91.1 pounds initial pressure. Our best performance of compounds to date, lies between the Leavitt engine at Louisville and the Rockwood at Natick, with records of 12.156 and 12.84 pounds of steam per horse power hour, with pressures of 151.6 and 175.5 pounds absolute, respectively. Allowing for the difference between the French and English H. P. (although M. Bollinckx does not state which he used) we have only 12.2 pounds per horse power hour, nearly equal to the Leavitt engine despite the difference in the initial pressures. The only engine performance in this country which can be compared to this, is the Milwaukee pumping engines, which are multiple expansion and have an initial gage pressure of about 150 pounds. Many of the details of this Bollinckx engine can be studied with profit by engine designers generally, and the causes for such an economy in steam consumption should not be difficult to find.

ADJUNCTS OF A MODERN RAILROAD STATION.

FRED H. COLVIN.

The passenger on one of the fast trains rolling into a fine terminal station, as he consults his watch to see if he is on time, thinks only of the powerful engine in the hands of two skilled men, of the good roadbed, easy riding cars, and marvels at the perfection of present day railroading which enables him to ride fifty or sixty miles an hour in greater safety than when half that speed was attained twenty years ago. He gives little or no thought to the numerous details which must be carefully designed and attended to in order that he may travel in safety and comfort, and as he glances at the finely equipped station on his way to the hotel, he thinks only of its pleasing appearance and not of the men and machinery that supply the necessary light, heat, water and other details. As an example of this we have taken some of the details which go to make the new Reading terminal station in Philadelphia such a complete and finely appointed station, as these details are extremely interesting to the mechanic and engineer. Although the pure water supplied to the station and cars running out of it is appreciated by the travellers, few know just how carefully this is prepared, and a little study of the refrigerating plant will be interesting and instructive. The plant contains two 75 ton Boyle refrigerating machines with 20 by 36 inch steam cylinders and 15 by 30 inch compressor cylinders, one machine being clearly shown by the engraving. The engines are of the Corliss type, built (engines and compressor) by the Pennsylvania Iron Works, of Philadelphia. These are supplied with steam at 100 pounds pressure from a battery of six internally fired marine type boilers from the Edge Moor Iron Works, which supply all the steam used in the different engines and appliances in the station. These are run continuously and burn from 35 to 40 tons of coal every twenty-four hours. Anhydrous ammonia is the refrigerating liquid employed in the plant, which on being compressed passes through the numerous coils of pipe in the condensers, which are huge tanks containing brine of such mixture (85 deg. Breame gage in this case), as to be "unfreezable" at the temperature employed. The ammonia thus absorbs the heat from the brine and is again vaporized by this heat, when it is pumped to the compressors once more, to go through the same cycle of absorbing heat from the brine again. The brine is also kept in circulation and in this case goes to the tank room, where 320 cans are immersed, each can making about 300 pounds of ice. The circulating pump is shown with its brine end covered with ice, condensed from the air of the room (which is about 75 degrees) and frozen into a solid mass, making quite a curiosity to those who are unaccustomed to ice machinery. Great care is exercised to have the water as pure as possible, and to this end the exhaust steam from the various engines is directed to a coke filter to extract all the oil that might be contained therein. From here it goes to a condenser, and thence to a reboiler and skimmer, which effectually robs it of all impurities, to a bone filter, thence through a cooling coil to a charcoal filter, and then to the storage tank. From the storage tank it is passed through a sponge filter, on the way to the freezing cans. This is the reason that Philadelphians wonder at the pure water supplied here, while the Schuylkill River may be indulging in a display of a coffee-colored mixture in the reservoirs and dwellings. The clearness and quality of the ice is said to depend on the time occupied in freezing, a quick freeze producing spongy ice with a large core, while a slow freeze gives clear ice and but little core; this plant averages about 57 hours to a freeze, keeping the brine at 15 deg. to 18 deg. Fahrenheit. The capacity is 20 tons of ice per twenty-four hours, 6 cans being drawn every hour, the remainder of the refrigerating plant being used in the cold storage rooms of the market, which is under the station.



ADJUNCTS OF A MODERN RAILROAD STATION.

The engineer may think for the moment that it is almost impossible to secure 20 tons of exhaust steam per day from a moderate sized plant, but a few calculations will perhaps reveal a far greater amount of water (or steam) than we dream of, that is daily going to waste in many places. Assuming 20 pounds of steam per horse power per hour, and few simple engines will do better than this in every day service, while 25 to 30 pounds is often used, and we have $20 \times 24 = 480$ pounds of steam per twenty-four hours for each horse power employed. Reducing 20 tons to pounds gives $20 \times 2{,}000 = 40{,}000$ pounds divided by $480 = 83.3$ horse power exerted continuously for twenty-four hours, not such a large plant as might be imagined. This ice is supplied to the terminal station, to all the cars running out of it and some of the stations along the road, and is appreciated by its patrons. The lighting plant is very complete, being equipped with 10 Western Electric arc machines of 30 lamps each, and Westinghouse alternators, all driven by Westinghouse compound engines. There is also one of the "Kodak" combinations made by this company, consisting of a small engine and dynamo coupled on one base. Air compressors of the Ingersoll-Sergeant type supply the compressed

air, at 80 pounds pressure, for the signals and switches and are placed in the main engine room, while the hydraulic elevator machinery is located in a sunken portion of the dynamo room, making a very complete and well equipped plant which, while little thought of by passengers, adds much to the service of the road and its patrons.

* * *

THINKING MEN.

H. A. Pedrick.

Every decade in these progressive times of mechanical skill and contrivances sees wonderful improvements, both in product turned out and the tools and machinery used in their production. The mechanic who is wide awake realizes these strides of progress, and must keep ahead of the procession or lose his identity. He has the chance to use his best talents, both natural and trained, for the further development of Nature's resources to serve the purpose of mankind in lessening physical labor and allowing all to have a share in its comforts and necessities, which, without his skill of production, would only be attained by the wealthy. The time was when a Brussels carpet was away beyond the reach of the mechanic. But now he can furnish his whole house with it if he wants to. Why? Is it because he is paid more money? No; but by his own skill he has been instrumental in producing a cold piece of machinery lessening human labor to such an extent that he can enjoy its benefit. The field for a mechanic's skill and ingenuity is widening every day. He is called on almost constantly to produce something that will reduce the cost of a product either too high in price to be of commercial value, or too delicate to be produced by other than accurate machine work.

The advantage the mechanic has to-day over the old-timers is the excellent periodicals devoted to his particular business, whereby he does not have to do it all himself to learn all about it, but if he is a close observer can gather points and information of great service to himself through our valuable mechanical papers. The observing man is the one who seems to get along so much more easily than the fellow who has no interest other than to get his day in. This type is quite abundant, and will always be found at menial labor, because he will not take enough interest in himself to get above it. Start two boys in the same shop under the same conditions; let one be interested in prize fights and such; the other boy employs his spare time reading papers and literature devoted to his craft, studying mechanical drawing and instructing himself in the elements valuable to his advancement. How is it that boy is picked out from the rest for promotion—is it because he has been more favored than the other one? No; it is because he has trained himself to use his head and hands, and that practice has qualified him to use his thinking-cap for himself, and his employers will soon recognize that he can use it for directing others. His superior knowledge and ability will crop out in the shop just as a bright new penny will shine among a lot of old ones. The opportunities of self-education to-day for mechanics is so thorough that none need lack the chance. Machine construction of to-day is no longer the heaping together of a lot of natural substances, but requires the best talents of the engineer, the draughtsman and mechanic. The best of each are the most successful, and in order not to fall behind he must in justice to himself avail himself of at least some of the avenues for higher education. We all learn from the experience of others, and have the advantage of beginning where some of our fathers left off. A young man of to-day does not want to be carried along with the current of progress, without any rudder or propelling power of his own to direct him from getting into some obscure place. But with steam up and fired by knowledge which is now available to the most humble among us, he can even propel himself against the current and reach almost any place he may find among the possibilities of a higher sphere. Competition among manufacturers require all to be equipped with the best and most modern tools and appliances, or fall behind those who are better equipped than themselves. Superior mechanical genius allows some to succeed in certain lines of work above the shop that has more expensive tools. The reason is clear. Suppose a well equipped shop has a large and expensive floor boring machine, with only an occasional job of work to do on it; the investment in such a machine will not be profitable unless it has sufficient work to keep it nearly always busy. But on the other hand a light, portable boring bar with a positive feed and bearings will be found in the shop not so well equipped in general machine tools. But by a little ingenuity that bar is brought out from its corner, bolted up to the job and work started on it, in some instances before the piece could be got into position on the large fixed machine. The money invested in the portable bar is insignificant compared with the fixed machine, and will pay largely on the investment even should it not be called in service except at intervals. Handy portable tools around the shop are a good paying investment, enabling their possessor to handle work along with his better equipped neighbor, in an up-to-date method, with the advantage of a smaller investment in capital, The modern equipped shop with its twenty ton traveling crane, is a splendid thing for handling work, but it has to be employed profitably and constantly, or the percentage of shop expense will run up pretty high. How about the man that has heavy pieces to handle and has no traveling crane, it is a clear case of doing the best he can. But with good portable tools and ingenuity he can in many cases let the piece lay and handle it so as to fairly compete with the other in the time required to do it. The time has gone by when work had to be designed to suit the tools of the shop. Now work is planned and tools and fixtures made to suit it. The process of machine construction is confined to planing, turning, boring, drilling, milling and grinding. The operation of using these machines or tools is the alphabet of the machinists' trade. The man who can handle one or all of them may be termed an expert in their manipulation; but put on a job in a Simon pure machine shop, where some of these facilities are lacking, would be a test of his ability to conjure something for a substitute to do the work. The man possessing sufficient ability under such adverse circumstances will generally be found a good leader, because he has learned to use his best endowment (brains) to help him out. The thinking man is the man who can see his way to do a piece of work with what he has at his command. True, it would not always be done to the best advantage, but it is a clear case of the thinking man's ability to take care of himself. The qualifications most necessary in one particular line of work is to do the thinking for others. The thinking man will command better pay, make better men, and command respect, bringing the trade in general into a more dignified position.

* * *

THE DESIGNING AND CONSTRUCTION OF MODERN STEAM ENGINES.—7.

Theo. F. Scheffler, Jr.

CONNECTING ROD.

In actual practice, after the size of cylinder has been decided upon, the connecting-rod should be designed before drawing the bed; after this has been done, a small paper templet can be cut out for an outline of rod of the same scale as intended bed drawing. Having done this, the templet can be used with the crank disc in proper place and a revolution made on the drawing to see if the rod and nuts on bottom will clear the bed frame. This is not always done, but will save an error now and then. It is desired that the body of rod should be rectanular through the the cross-section; that is, between the stub ends of rod. To calculate the necessary number of square inches at center of rod, we will first assume the rod to be round, and then find the equivalent number of square inches for a rectangular cross-section, applying the following formula:

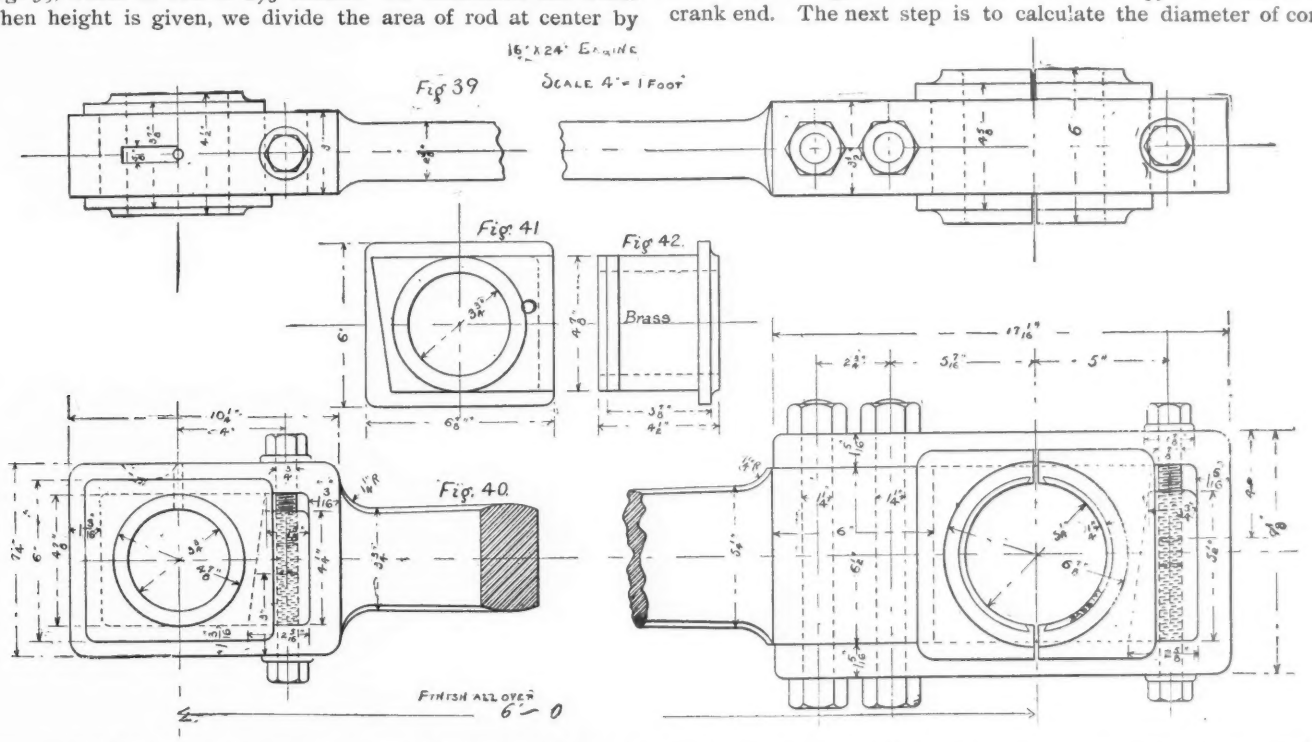
Let D=diameter at middle of rod in inches,
" L=length of stroke in feet,
" P=total load on piston,
".022=a constant,
" 10=a constant,

then $$D=.022\sqrt{10\,L\,\sqrt{P}+P}$$

Let L=2,
" P=25125,

then $$D=.022\sqrt{10\times2\times\sqrt{25125}+25125}=3.69$$

inches diameter at center of rod. This is practically equivalent to $3\frac{11}{16}$ inches diameter; the area of $3\frac{11}{16}$ inches is 10.67 square inches. To find the maximum pressure per square inch, divide 25476.75 pounds by 10.67; this gives 2387.6 pounds. The figure 25476.75 is the maximum pressure when crosshead is in center of stroke, due to the angularity of rod. To calculate the proper size of connecting-rod at center for a rectangular cross-section, we will first refer to drawings. Fig. 39 is a plan view, Fig. 40 a side elevation of rod, and Figs. 41 and 42 a detail of brass box for crosshead end showing side and end view. To return to body of rod, referring to Fig. 40, it will be observed that the small end of rod is $3\frac{3}{4}$ inches and the large end $5\frac{1}{4}$ inches, and adding together gives 9 inches; and for average height, or at center, we divide by 2, which gives $4\frac{1}{2}$ inches. Referring to Fig. 39, width of rod is $2\frac{3}{8}$ inches. To determine the width when height is given, we divide the area of rod at center by



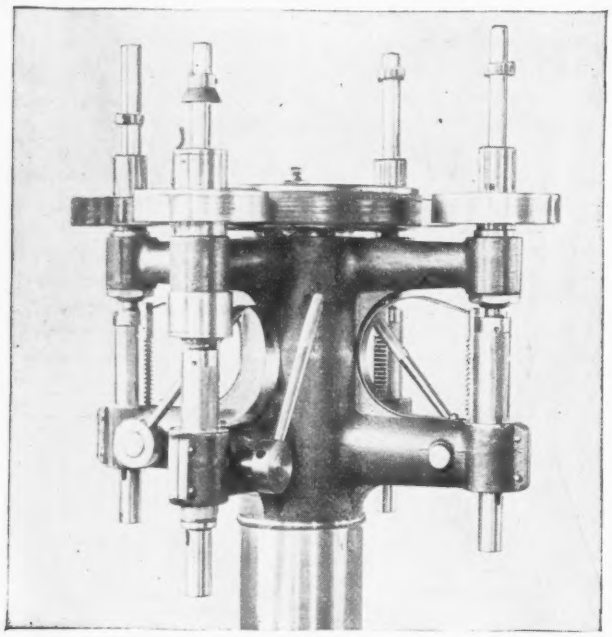
average height, thus: Area 10.67÷4½ height=2.36 inches for width of body of rod; this is practically $2\frac{3}{8}$ inches. Therefore, the rectangular cross-section of rod is $2\frac{3}{8}\times4\frac{1}{2}$ inches. It will be but slightly reduced in area by turning the rod, as shown in drawing. The maximum stress on small end of rod should not exceed 4,000 pounds per square inch. We find by multiplying $2\frac{3}{8}\times3\frac{3}{4}$ inches gives 8.9 square inches for area of rod at small end, and by dividing 25,476.75 by 8.9 gives only 2,862 pounds per square inch. The size at the small end in height could be somewhat reduced, as we have such a large factor of safety, but to have a good appearing rod when finished it is better to make small end $3\frac{3}{4}$ inches in height and connect at center with the $4\frac{1}{2}$ inches in height, which, when continued to end of rod, gives $5\frac{1}{4}$ inches. Another good plan for height of rod on each end is to make small end same as diameter of crosshead pin, and large end the same diameter as crank-pin. Of course in this case it would be necessary to calculate the diameter of pins first. Having found the diameter, the width of rod can be easily determined by the rule already given for the rod. In case it is desired to have a round connecting-rod body, the formula given will be correct, and in this case would be $3\frac{11}{16}$ inches in diameter, but the rectangular rod is the stronger of the two. In very high speed engines it is much better to use a constant of .025 in figuring diameter of rod, instead of .022, which was used in this case. We will now calculate the size of connecting-rod straps, which we will assume to be of best hammered wrought iron. It is best to allow a pressure of 5,000 pounds per square inch of cross-section. As the total pressure on rod is 25,476 pounds, dividing by 5,000 gives 5.09 square inches required at smallest point; this, of course, on crosshead end will be through center of wedge-bolt. Assuming that our strap is to be 3 inches wide over all, we will deduct out the ¾ inch bolt, which gives 2¼ inches for actual effective width in figuring area; and as we require only one-half of 5.09 square inches in each leg of strap, divide by 2, this gives 2.54 square inches; this 2.54÷2.25 gives 1.131 inches for thickness of each leg; this is practically $1\frac{3}{16}$ inches, and is the required thickness of crosshead strap. It will be observed by referring to Fig. 40 that the connecting-rod on crosshead end is forged solid, and the crank end fitted with strap, but this being so, the calculation for crosshead end will be as figured, whether solid or fitted with a strap. The crank end of connecting-rod is calculated the same way, but in this case the weakest point of strap is through center of the 1¼ inch driven bolt. As the width of strap on crank end is 3½ inches over all, and deducting out the 1¼ inch bolt, gives 2¼ inches for actual effective width in figuring area; and as in the crosshead end we require only 2.54 square inches in each leg at smallest point, we divide again by 2.25 inches; this gives 1.131 nches for thickness, but as the strap will be somewhat weakened by having two holes on each side, some allowance should be made for drilling, so that we will call this $1\frac{5}{16}$ inches thick at crank end. The next step is to calculate the diameter of connecting-rod driven bolts; taking the same stress, 25,476 pounds; the bolts we will assume to be made of best machinery steel, and as there are two bolts, the stress will be divided between the four shearing points, two in each leg of strap. Therefore, 25,476÷4 =6,369 pounds that each shearing point of bolt must be capable of holding with safety. The ultimate shearing strenth of steel is about 72 per cent. of its tensile strength, and assuming steel to be 60,000 pounds for tensile, and multiplying by .72 gives 43,200 pounds for shearing per square inch, and allowing a factor of 8, we divide 43,200 by 8, which gives 5,400 pounds per square inch; and dividing 6,369 by 5,400 gives 1.17 square inches area for bolt. This area is equivalent to a bolt between $1\frac{3}{16}$ and 1¼ inches diameter, but would be called 1¼ inches for safety. The small bolt has no stress upon it except for adjusting wedge, and will be sufficiently strong if made ¾ inch at small end and ⅞ inch at large end of straps. The crank-box is brass and lined with babbitt metal, the crosshead box has no babbitt. The wedges are much more satisfactory than a key for taking up wear, as they always have a full bearing the width of straps, while the keys only bear on edge, which allows the boxes after wear, to vibrate at center. The next article of this series will contain fricton absorbed by crank-pin; also crank-disc and shafts, with necessary calculations.

* * *

LET us have that last home-made device, it may help others.

A NEW TURRET DRILL.

We illustrate the head of this drill enlarged to show one spindle arranged for automatic tapping, and with three drill spindles. The turret holding the four working spindles swings on the main column, and is set rigidly by a heavy spring stop when any spindle comes directly over the center of the table. The driving is entirely by friction, the top wheel being keyed to the main shaft, which is held in an adjustable box at the top, having a Vanderbeek universal joint between this and the



lower bearing. The shaft is eccentric with the column, so that only the front spindle pulley is in contact. The spindle in use being the only one in contact with the friction, saves wear on those not in use. As only one spindle is in operation at once, the feature of arranging one of the four spindles with an automatic tapping device is a very practical addition, giving the operator three drill spindles and one tapping spindle that can be used at will. The lower friction is an inverted disc as the driven, and a splined wheel as the driver. The speed is varied by moving the latter on the splined shaft by the foot levers in front, changing the speed of any spindle at any time in a ratio of 1 to 5. This, together with the new friction countershaft which is supplied with it, make an almost infinite variety of speeds possible. The machine is certainly unique in many ways, and the construction is believed to be entirely new. It is made by the States Machine Co., Hartford, Conn., who will give any further information.

* * *

A FEW "KINKLETS."

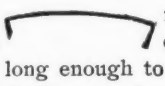
F. RIDDELL.

While each engineer as a general thing conceives it to be his duty to give his fellows the benefit of his experience along the lines of the greater things of his profession, there are numerous lesser things which each one has to find out for himself—and after finding out keeps to himself—not because he is selfish, but because if he thinks of them at all, he considers that they are of too small value to interest others of the craft.

That the engineer is not alone in this is proved by the continual appeals made by all trade papers for "kinks" in the line of labor which they represent; some going so far as to offer prizes of greater or less value for descriptions, with cuts, etc., of the various "home-made" appliances.

One reason why it is necessary to offer such inducements is the feeling that every one probably knows all about it already, if it is of any value, and yet such is the variety of ability in the numerous lines of work that new things are continually being thought of which, if generally known, would be as a whole, of a good deal of advantage to the world of labor.

Two or three little "quirks" hardly reaching the dignity of "kinks," and therefore given the name at the head of this article, have occurred to me within a few weeks and are hereby tranferred to these columns for the benefit of "whom it may concern."

One of the standing injunctions of many manufacturers of packing is, "Don't screw up the gland too tight, no tighter than you can turn it with your fingers; although it will leak steam a little at first, it will soon stop." But when the nuts were just turned up with the fingers they would seldom stay so, but would back off, thus leading to a flow of rather hard thoughts, even if the appropriate language to match them was suppressed. Desiring to give some packing I had put in a fair trial, and determined to keep the nuts from backing off, I took a piece of wire and bent it thus:  making the curve in the center high enough to clear the valve-stem, and the hooks at the end long enough to lie flat along the sides of the hexagon nuts. And they stayed.

On starting up recently after a couple of weeks' shut-down for repairs, the governor belt on one of my engines acted rather badly. It had become somewhat soaked with oil from the main bearing the collar of which, for some reason, seemed to drop the oil off at the top instead of the bottom. Thinking that a slight roughness might cause this, every care was taken to polish it; but though it was seemingly as smooth as metal could be made, no improvement in its action was perceptible. Having put on a new belt I took a string of candle wicking and, catching it around the collar, let it wind on without drawing into the shoulder between the collar and the pillow block. Since that time no oil stains appear on the new belt, and the longstanding trouble seems to be at an end.

My engines have rather long feed-pipes, and the pipe to the gages in the engine-room are also quite long. About once in two or three months I have to take down one of these pipes, disconnecting it near where it leaves the main pipe, when it will be found plugged up for two or three inches with a kind of greasy stuff which prevented the steam pressure from reaching the gage until it got quite high, when it would seem to filter through, and after an hour or so would catch up with the other, while the other one is always reliable. What causes the difference? Simply this; that the troublesome one is tapped into the top of a horizontal main, while the other enters at the side! Any one putting up pipes may save the man who has to take care of them much trouble by a little attention to small matters like this.

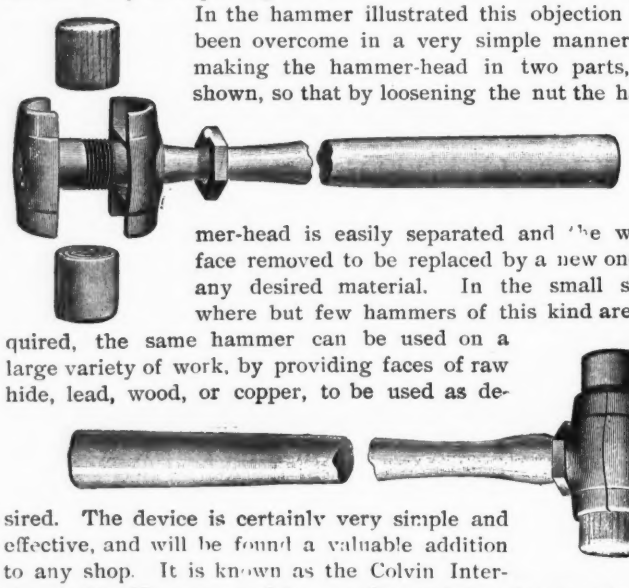
Since beginning this article my attention has been forcibly called to another matter, for one of my engines (a Corliss, 18 by 42) started to run away, for the first time since I made its acquaintance, nearly a decade ago. Fortunately I was near by, and succeeded in stopping it without any damage being done, and in looking around for the cause found one of the governor arms had dropped down, the nut holding the rod to the "clevis" which connects to the top of the spindle, having worked off.

The kinklet in this case is one which was immediately put in practice. The governors of both my engines were closely examined to see if any more nuts were loose, and this examination will be from this time forward, frequently repeated.

* * *

A NEW "SOFT" HAMMER.

Every shop knows, or should know, the value of "soft" hammers, and one of the drawbacks to their more extended use is the difficulty in replacing old and worn faces with new ones. In the hammer illustrated this objection has been overcome in a very simple manner by making the hammer-head in two parts, as shown, so that by loosening the nut the hammer-head is easily separated and the worn face removed to be replaced by a new one of any desired material. In the small shop where but few hammers of this kind are required, the same hammer can be used on a large variety of work, by providing faces of raw hide, lead, wood, or copper, to be used as desired. The device is certainly very simple and effective, and will be found a valuable addition to any shop. It is known as the Colvin Interchangeable Hammer, and is manufactured for Greene, Tweed & Co., 85 Chambers street, New York.



ABOUT ENGINES AND BOILERS.

F. F. HEMENWAY.

A correspondent asks us several questions in relation to the horse power of engines and boilers. In a general way it may be said that neither engine nor boiler possesses anything that can be termed horse power, any more than a bar of iron or steel, lying inert, possesses the quality of horse power.

When an engine is in motion, backed by a definite steam pressure behind the piston, then a certain horse power is being developed. But what this power will be depends upon a variety of conditions that need not be explained here.

Taking the conditions most ordinarily met with in practice, viz.: steam pressure 70 to 100 pounds, engine well constructed, we are not likely to be far out of the way if we consider the power of the engine to be concluded in its reasonable capacity by the limit of one-half the boiler pressure; this without reference as to whether the engine is or is not automatic cut-off, although in the instance of some types of automatic engines in which the steam must be cut off materially before half-stroke, if at all, some allowance may be necessary.

In general practice, however, we may assume that we can depend upon a mean effective pressure equal to one-half the boiler pressure we then have for probable power of engine; multiply the area of piston in inches by the assumed steam pressure (one-half boiler pressure), multiply this by piston speed in feet per minute and divide the final product by 33,000.

I may be allowed, even in MACHINERY, to put this a little plainer in the way of a formula, because I know from personal experience how few mechanics have ever given attention to horse power. But I shall not insult the readers of MACHINERY by too much in the way of explanation.

Let us say: Area of piston = 90 inches, one-half boiler pressure = 40 pounds, and speed of piston = 500 feet per minute; then we have, in the homeliest little formula in the world, this:

$$\frac{90 \times 40 \times 500}{33{,}000} = 54$$

horse power. Every one who has read at all on the subject knows that 33,000 pounds lifted one foot high in one minute is supposed to equal the effort of one horse. The word *supposed* is used purposely, because I do not believe a horse can do anything of the kind, but it does not matter whether he can or not. I want to make it reasonably plain that the term horse power is purely conventional, and really means nothing. We could put any expression in its place, and so far as the expression went would know just as much about the whole matter.

Just as a personal expression of opinion I think it is high time it was cut out of the English language.

When it comes to the horse power of a boiler the matter is more complicated. There is nothing to measure by, unless we are willing to agree with the terms of others. The A. S. M. E. have advised that the evaporation of 34½ pounds of water shall be considered as the equivalent of a horse power in a boiler. This appears to be very plain, but whether a boiler will or will not do this must depend upon a test. It can be settled in no other way. You cannot measure anything without a standard of measurement

On general principles about 12½ feet of heating surface is required per horse power of boiler. But one-quarter of this surface may be sufficient under certain conditions.

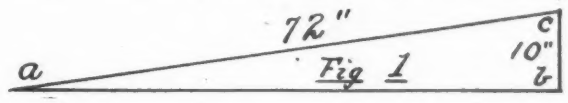
PRESSURE ON GUIDES.

Another reader sends us a sketch of a 14 by 20 inch engine, and wants to know what the pressure on the guides will be when the crank stands at right angles with the center line of motion (of which the piston-rod may be taken as an example), in other words, when the crank is at half-stroke position. At this time the pressure on the guides will be greatest. The reproduction of our correspondent's sketch is not necessary, hence we omit it.

To solve the problem we first draw the line *a b*, Fig. 1, of any length, so it be long enough; then perpendicular (at right angles) to this line we draw the line *b c* of a length equal to that of the crank, in this case 10 inches. From *c* draw the line *c a*, which shall be exactly the length of the connecting-rod, 72 inches, where it meets the line *a b*, giving no attention to the length of the line *a b*; that we have yet to find by calculation.

We have now a right-angled triangle, and we know the length of two sides. One of these sides being the side opposite the angle (the hypothenuse) represented by *c a*, we can readily find the other side, *a b*. To do this we square the length of side *c a*, 72×72, which gives us 5,184; then square the length of side *b c*, 10×10, which gives us 100; subtract 100 from 5,184 and we have 5,084, the square root of which is 71.3, very nearly. This is the length of side *a b*.

We want the *total* pressure on the piston; the area of the piston is 154 square inches, and the steam pressure is 70 pounds; multiplying 154 by 70, the product is 10,780. This, in pounds, is the total pressure on the piston, so that the side *a b* not only represents 71.3 inches, but it represents 10,780 pounds with which it is loaded. Now, in a parallelogram of forces, from which Fig. 1



was evolved, the forces are in proportion to the lengths of the sides, hence we have all the elements necessary to solve the problem by simple proportion: 71.3 : 10 :: 10780 : to the pressure on the guides. Multiplying 10,780 by 10 and dividing the product by 71.3 we get the answer, viz.: 1,511 + pounds. If our correspondent wishes to fully understand the *whys* of the operation he may need to study up a little on the parallelogram of forces, if he is not already well posted. If he objects to finding the length of side *a b* by calculation he can measure it. We consider it much more accurate to find it by calculation than to trust to a drawing and measurement. When found by calculation in this case no drawing at all is necessary, the sketch being given for convenience of explanation only. If found by measurement an accurate drawing is required, and errors in measurement must be submitted to.

Another method much more simple may be given. It is not so exact as the former method, but with length of connecting-rod generally used in American stationary engine practice, it answers all practical purposes. Referring to the same figure as in the preceding example, we divide the length of line *b c* (10 inches) by length of line *c a* (72 inches) and multiply the quotient by the total pressure on the piston; that is, we divide 10 by 72 and multiply by 10,780. In this case we can readily perform the operation by annexing a cipher to 10,780 and dividing it by 72. Doing this we get 1,497 pounds as the pressure on the guides.

The difference in this case is so trifling as not to be worth noticing. It should be noted however, that as the connecting-rod is shortened this difference increases. Thus with a connecting-rod only four cranks (40 inches) long the difference will be 88 pounds. This solution, as will be seen, requires no drawing.

The foregoing solutions are based upon the center of crank-shaft, being neither above nor below the center line of motion.

The way to proceed to find the pressure on the guides when the crank is at any position in its revolution will readily suggest itself, and is not asked for by our correspondent.

In the foregoing no account has been taken of the weight of crosshead and so much of connecting-rod as is represented by downward pressure. This would add to or take from the pressure on guides a little, according as the engine is run over or under, but for all ordinary purposes may be neglected.

The type last month made me say "short fronted," "long fronted," etc., instead of "ported," in regard to the engines on the B. & A. R. R., and it will please the older readers to have this corrected.

* * *

NOTES FROM THE WORKSHOPS.—2.

A. LEARNER.

The boss's attention was here attracted to the moving of a large turret lathe, which in its completed condition, fastened on skids, was just now initiating a movement, to be continued on dray and rail across the country to its destination.

When he was again at liberty he was asked the question: "How small a chip can you turn with a turning tool, from a piece of round steel, in the best modern lathe?" He appeared to consider the question seriously for a short time, and then replied: "I can take six or eight cuts to reduce the piece a thousandth of an inch." "What kind of a tool will you use?" "A racker."

It is still an open question whether or not his ideas were in such

a confused and distracted condition at that moment that he was not really responsible for what he said.

The question and its answer were repeated to a plain, practical, every-day sort of lathesman, who has done nothing for the last twenty years, to my certain knowledge, but stand in front of a lathe and watch the lathe tool cut chips from all sorts of steel and iron turning. "I don't know," he said; "I never tried." He was told what had been said, and replied: "That would be nothing but scraping dust. Do you know how fine a thousandth of an inch is? Let me have a hair and measure it, so you will see what they mean when they talk about a hair's breadth." He put a hair into his micrometer. It was not so tight but that it would pull through freely at 1½ thousandths. We called it a 2 thousandth. By the same micrometer the paper of a daily newspaper measured .0035 inch.

"Now you take that hair," he said, "and divide that two thousandths of an inch into twelve or sixteen parts and you have the thickness of the chip that would come off in taking six or eight cuts to reduce a piece of work a thousanth of an inch. I shouldn't know what fluid to use to turn it in; certainly not any kind of oil, nor soda water, nor pure water; you might turn it absolutely dry, only you'd touch it with your hands, or even the moisture of your breath would make a difference when you work so fine. May be a solution of carbolic acid would do: it is good to use on a whetstone and lets the steel right on to the stone; camphor dissolved in spirits might do. What kind of a tool would I use? A flat nose, leading side the highest, following side just off the work and hard, hard as the hinges of Jophet. Break? No! not if the angle isn't too acute; you can get a sharp edge without an acute angle. I have heard men that bore out gun-barrels say that there was a man once who ground the corner of a square bar so sharp that it would cut a hair." After this statement it seemed necessary for the interviewer to retire to prevent the lathesman from being astonished by hearing an explosive burst of incredulity.

Speaking afterwards to another person about the effect of touching with the hands a piece of work that is to be cut, he said: "I can tell you a little case of that kind. I was planing a platen for a 7 spindle gang drill, and I left a little to take off with a finishing cut, and some "fool feller" came along at dinner time and stood with his sweaty hand resting upon it. I noticed the mark and was afraid it would make trouble for me, and it did; for after I had taken what I calculated was to be the finishing cut over it, there was the mark of that hand, in raised work, as plain as could be. I had to take yet another cut to get it to a uniform surface. I think, though, about that fine, close turning, that if you are careful enough you can do it dry. You can scrape a flat surface and take off as little as you please, and if you have a perfect lathe and the centers fit, there is no limit to the closeness you can set.

Talking with another man, whose business was the making of round holes in which the needle-bar ot a sewing machine plays, he said: "It is impossible to say, when you take up one of a thousand cast iron needle arms, that when you have passed your reamer through it, the hole will be of the same size as the last one you have reamed, or of the next one you may ream. It may be larger or smaller than either one of them, and yet the difference in size be so very minute that it is not practicable to make reamers vary so little as to correct the holes. It is not practicable to keep a reamer for cast iron to such a keen edge that it will enlarge a hole a half of a thousandth of an inch." "How is that? they will come closer than that in rifle-barrel reaming." "Yes, I know that, for that's my regular trade; but how do we do it? We run our reamers deluged in oil; they are square and one edge is as sharp as it can be. I've heard of a man who sharpened the edge of a square reamer so fine it would cut a hair"—and we always keep them sharp. "Then we pack in on one side of this reamer the thinnest kind of tissue paper, and that only enlarges the reamer a little more than half or three-quarters of the thickness of the paper. These reamers run slow and steady, and cut microscopic chips in iron or steel gun-barrels; but you try to enlarge one of these holes in cast iron with a common reamer a half a thousanth and your reamer will jam in and pinch and tear, and won't cut." Well, if you can't cut them, how do you get the holes all to one size?" "I drift them. Understand you, now, I don't broach them, I drive a straight plug through them. I grease the plug, and by driving it through I can easily enlarge a hole from a quarter to half a thousandth of an inch. It don't take the metal out, but it drives it back, makes a nice, smooth hole, and leaves a good bearing surface inside." That is what might be called an operation on the pressure, or stamping principle. Come to think of it, isn't the finest metal work done on this plan—coining, for instance?

I went to a man who I knew to be a first-class close workman. He put a rod of quarter-inch round steel into the chuck of his Waltham Watch Tool Co.'s bench lathe and reduced a place on it an inch and a half a quarter of a thousanth of an inch, but not at the first trial.

The idea that I am ruminating upon is the practicability of making very slight reductions in size by turning between centers, and my mind fixes upon steel a half inch or more in diameter and six inches or more in length as the dimensions of the work. I think most lathesmen would be content if they could depend with certainty upon their ability to reduce the size, without dodging or evasion, a thousandth of an inch at a cut and that any less than this amount they would generally remove with a file. I have heard that the requisites for turning close are, as to the lathe, a close fitting spindle, truly ground centers, undeviating, unintermitting tool progression; as to the tool, hardness, tenacity and correct form; as to the work, uniformity of surface conditions, of texture and of hardness; the center holes must fit the lathe centers and have ample bearings thereon; as to the speed, it must not engender heat to disturb the requisite conditions of equable temperature; neither the tool nor the work should accumlate heat.

* * *

WHAT MECHANICS THINK.

THIS COLUMN IS OPEN FOR THE EXPRESSION OF PRACTICAL IDEAS OF INTEREST, TECHNICAL OR OTHERWISE. WRITE ON ONE SIDE OF THE PAPER ONLY, AND BOIL IT DOWN.

WHEN SKETCHES ARE NECESSARY TO ILLUSTRATE THE IDEA, SEND THEM ALONG—NO MATTER HOW ROUGH THEY MAY BE, WE WILL SEE THAT THEY ARE PROPERLY REPRODUCED.

SAFETY SPEED OF FLY-WHEELS.

We requested the opinion of Mr. James Christie, chief engineer of the Pencoyd Iron Works, regarding the safe speed of fly-wheels in rolling-mill service, and believe that his reply will be interesting and valuable to our readers as coming from an acknowledged authority. We quote:

"I consider about 8,000 feet per minute as the extreme peripheral speed at which cast-iron fly-wheels should revolve. When higher speeds are desired, the castings should be of steel. Even at this speed the wheel should be carefully designed for the purpose. It is frequently the case that wheels are not made to properly resist transverse stress in the rim due to centrifugal force, as described by Mr. Stanwood in a paper before the A. S. M. E., a couple of years ago. I can recall at least two instances where large pulleys burst, the character of the break clearly indicating that the destructive stress was of this character. I am aware that the speed named is higher than is allowed by some authorities; a mile a minute used to be an old rule-of-thumb for limiting speed, but there is enough precedent for this speed. For examples in this vicinity, a 14 foot fly-wheel, 10 tons weight, has run for many years 150 to 180 revolutions per minute, and occasionally somewhat faster. A 25 foot wheel, 25 tons weight, has run constantly 80 to 90 revolutions, and occasionally 100. These, of course, are extreme cases, and cited as such. When wheels have to run at such speeds they should be the subject of critical inspection, both for design and nature of material.

"Writing to you a few days ago on speed of fly-wheels, when citing instances of high speed wheels, I omitted the case of two small cast iron wheels, under my observation. These wheels are 2 feet outside diameter, and run 1,500 revolutions per minute. The rims are 33 inches wide and 2½ inches deep, have a continuous web connecting to hub, and of course are accurately balanced, being turned all over. The periphery of these wheels runs about 9,400 feet per minute; owing to their small diameter, the velocity at center of gyration would not so largely exceed that of the large wheels previously cited, as might appear."

Pencoyd, Pa. JAMES CHRISTIE.

A CRITICISM.

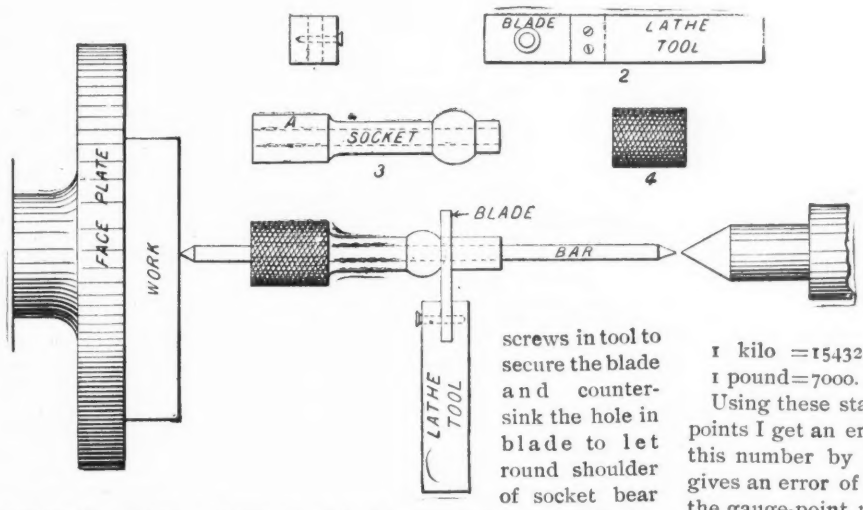
In Mr. Scheffler's article on crossheads he says that 1⅛ cast iron walls are as good as ¾ inch in a steel casting, and as far as strength and cost is concerned I agree with him. But in an engine, particularly one for high or medium speed, the weight of

reciprocating parts should be as small as possible, so as to lessen the required counter-balance in the crank-disc, or the unbalanced effect where the fly-wheel alone is depended on to receive and absorb it. Then the advocacy of the jamb-nut is rather surprising, for although superior to the key, it has the same faults in a milder form, and is not so good as the method I mentioned of Prof. Sweet's, or of the Altoona Mfg. Co., described in the March number. Regarding unbalanced valves the fact is too often lost sight of that the valves are only unbalanced until the steam port just opens; and also that compression relieves and often overcomes the pressure on back of valves. Balanced valves are a good thing when properly made, but don't think that the unbalanced pressure exists during the entire stroke. "WHYNOT."

ANOTHER CENTER INDICATOR

As I looked over November number of MACHINERY I saw a cheap indicator. In the tool room where I work we have one that is simple and cheap; it may be old to some and new to others, and I send you a sketch of one.

Take an old lathe tool and slot it at one end about $\frac{1}{16}$ inch wide and 1½ inch long, and insert a piece of sheet steel of the same width and 3½ inches long, which will do for a blade. Put two



screws in tool to secure the blade and countersink the hole in blade to let round shoulder of socket bear against it. Then a piece of ⅛ inch round steel rod 10 inches long with point at each end for indicator needle. Then make a socket to fit over the bar, not too slack, and about 2½ inches long, at end A slot in four places so that when the cap is placed on it will tighten the socket upon the bar. Now the cap, which is knurled with very little taper inside. By tightening tool in tool-post and bringing carriage tightly up against the ball shoulder and turning face-plate by hand, you will soon find center.

Montreal, Canada. G. LESLIE ATHERTON.

A CORRECTION.

Under the heading of "For Our Designer's Note Book" in the January issue of MACHINERY, the writer gave a formula for determining the diameter of the smallest step of a cone pulley for a back-geared machine, when it is required that the speed of the machine shall be decreased in arithmetical progression as the belt is shifted from the smallest step, with the back gears out of mesh, to each successive larger step and back again to the smallest step, with the back gears in mesh.

The formula given reads,

$$d^2 = \frac{D^2}{R^{\frac{s}{s-1}}}$$

while it should read

$$d^2 = \frac{D^2}{R^{\frac{s-1}{s}}}$$

Substituting the given values of D, R, and s, we have

$$d^2 = \frac{30^2}{(15.74)^{\frac{5-1}{5}}}$$

Solving by means of logarithms,

$$d^2 = \frac{1.477121 \times 2}{\left(\frac{1.197005}{5}\right) \times 4}$$

$$= 1.9996638$$

$$\therefore d = \frac{1.996638}{2}$$

$$= .998319 = 9.96 \text{ answer.}$$

H. M. NORRIS.

SOME INFORMATION ABOUT THE SLIDE RULE.

I have been much interested in the articles in MACHINERY on the slide rule, by William Cox, and I have gained some points from them. I have been struggling for some time with a slide rule, but have not been able to master it as yet. I am able to do a great deal more with it than I could at first, but am afraid I shall never become proficient in its use.

My rule is the "Mannheim," from Messrs. Keuffel & Esser, and seems to be well made. I will give an example: What is the area of a circle 34 inches in diameter? I set the slide to gauge point given on scale B and over 34 on scale D. I find 91 on scale B. Now to work out this problem by the regular formula ($34^2 \times .7854$) I get for my answer 90.792+. Now what I would like to know is this: Is there any way by which I can read the result on the slide rule so as to get an answer nearer than .91?

In my business I have occasion to figure on the weights for foreign standards; I wanted gauge-points for kilo. to libra:

1 kilo. = 15432.349 grains.

1 libra = 7112.67 grains.

After a great many trials I found that 165 : 358 would give correct results within .011 of a grain on one kilo. This is near enough for all practical purposes, but I would like to know if there is any way to find gauge-points that would give any closer results, and also if there is any shorter way to get them than by repeated trials.

In the table of gauge-points on the back of my slide rule I find the following:

Pounds : kilogs. = 75 : 34.

Our standards are:

1 kilo = 15432.349 grains.

1 pound = 7000. grains.

Using these standards in connection with the above gauge-points I get an error of 8.8275 grains on one kilo.; multiplying this number by 50 kilos. (as I often have occasion to) and it gives an error of 441.375 grains, or over 1 ounce, which makes the gauge-point practically useless. I have also been trying to find gauge-points that would come nearer, but have not succeeded yet in getting any that suited me; the nearest I have found at this writing are 97 : 44. These give an error of .53 grain per kilo., or 26.5 grains per 50 kilos. This is not near enough, and I shall try and find something nearer as soon as I can find the time to work it out by my own slow process.

I have only mentioned a few of the many difficulties I have encountered in trying to master the slide rule. But I am not ready to give it up yet, and hope by the aid of the articles in your welcome paper, and such information as I am able to pick up from other sources, to eventually attain a fair degree of proficiency in the use of this wonderful instrument. SLIDE RULE.

In reply to "Slide Rule," it seems to me that he expects too much from an instrument of such limited dimensions. Taking, however, his first problem, I find that 34 on scale D does not exactly coincide with 91 on scale B, but comes a little short of it, and by estimation I should make the result 908, which is very near the correct solution, 907.92... Greater accuracy than this must not be looked for or expected. The gauge-points used in this case, 14 and 11, are equivalent to 0.7857, which is as near to 0.7854 as can be set on the slide rule. There is no short or easy method of finding gauge-points, but they must all be calculated, many trials being necessary before satisfactory ones are found. It must be remembered that the slide rule cannot give results more accurate than one is capable of estimating subdivisions of the spaces, the generally allowed error for careful work being one in 1,000. With larger slide rules, and especially with the Thacher, greater accuracy can of course be obtained, and such instruments should be used in the office when approximate results do not suffice for the special work in hand.

Stapleton, N. Y. WM. COX.

MORE ABOUT DRILLING VALVES.

I would like to submit some figures coming under my notice, and bearing on a point raised by H. Heyrodt, in his article in the February issue. His plan of giving lap sufficient to cause necessary compression is impracticable, as the ports of modern engines are designed so closely as not to allow any contracting. If eccentric throw was changed to allow this, the governor would have to

be changed, and steam chest would then be too short. His objection to "folly" of drilling the valves of Corliss engines is that it makes a rounded cut-off (?), thereby impairing economy. That this is more imaginary than real, the following rough figures taken from a case occurring here, would tend to show: Corliss engine, condensing, 36×60; revolutions per minute, 54; pressure, 90 pounds by gauge; clearance, 3 per cent; vacuum, 26". Twenty pounds by gauge terminal pressure to stop pounding. Amount of steam let through holes =

$$\frac{1.8 \times 1017.8}{1728} = 106$$

cubic clearance volume feet, or .0905 pounds of steam. The amount is a direct function of difference of pressure and of time. The steam was admitted during 5 per cent. of piston travel while crank turned 15 degrees, or the time = $\frac{1}{6}$ of time of 1 stroke; difference in pressure = abont 90 pounds on the average. At cut-off the time taken to effect drop cut-off is while crank travels less than 2 inches, or $\frac{1}{47}$ of time of 1 stroke. The difference in pressure at $\frac{1}{4}$ cut-off for this distance is less than 8 pounds on the average. Hence the amount of steam admitted and tending to disturb cut-off =

$$\frac{.0905 \text{ pounds} \times \frac{1}{47} \text{ (time)} \times 8 \text{ (diff. of pressure)}}{\frac{1}{6} \text{ (time)} \times 90 \text{ (diff. of pressure)}} = .001 \text{ pounds.}$$

Amount of steam in cylinder at $\frac{1}{4}$ cut-off, =2.125 pounds; per cent. of steam tending to round cut-off

$$= \frac{.001}{2.125} = .00047 = \text{less than } \frac{5}{1000} \text{ of 1 per cent.}$$

That this should disturb the economy of an engine seems to be due not to the holes in valve, but to either poorly adjusted drop cut-off, faulty indicator motion, or a powerful imagination.

Butler, Pa, GEO. E. HOWARD, M. E.

* * *

MACHINE DRAWING AND DESIGNING.

The highest efficiency in this line is not necessarily with those who can make the most artistic show on paper, and whose style of design is the most attractive to a fanciful imaginative eye.

Any machine or tool design should always be as simple and free from defects as possible. Where any piece of mechanism is desired to accomplish a certain work, if it can be made of one piece of metal, of proper strength and shape, it is better to do so than to make it of many parts joined together, unless sufficient reasons appear that cost of production and convenience of adjustment should demand it. The best efficiency, as a rule, on this line is always met in that class who are practical machinists, with sufficient knowledge of mathematics and other useful theoretical formula to meet the demands of their needs (and are not burdened with unnecessary theoretical ballast). The men who can *originate* mechanical devices for needed purposes, whether they are machines or tools, naturally enough have a first and important part in mechanical work both as thinking how to construct, and how to convey to others who assist in executing construction, their ideas intelligently by placing them on paper.—From catalogue of Francis W. Clough Springfield, Mass.

* * *

The index to advertisements will be found on page 5.

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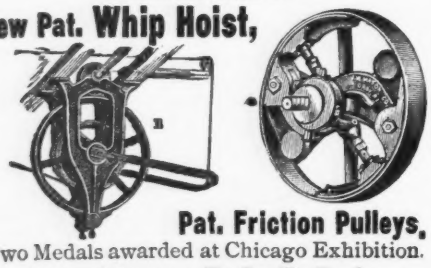

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MANUFACTURING NOTES.

THE Feed Water Heater Manufacturers Association, at a recent meeting adop ed the commendable resolution of rating feed-water heaters by the square feet of heating surface they contain, and to state this in every case when making prices. They also agree to state in all catalogs and specifications the diameter of tubes, number of lineal feet thereof, and total square feet of heating surface. This is signed by The Taunton Locomotive Mfg. Co., Benj. F. Kelley & Son, Wm. Baragwanath & Son, The Goubert Mfg. Co., The National Pipe Bending Co., Robt. Wetherill & Co., and Keystone Engine & Machine Works.

FRESH FROM THE PRESS.

THE ELECTRIC HEAT ALARM CO. Boston, send a neat catalog showing application of their thermostats to various places, such as hotels, grain elevators, line shafting, etc., to give fire alarm when temperature exceeds a predetermined point.

THE SLIDE RULE: Wm. Cox. Keuffel & Esser Co., 127 Fulton street, New York. With the aid of this manual and one of the "Mannheim" rules made by this company, the engineer will be well equipped to not only become thoroughly familiar with the use of the rule, but to apply it to his everyday calculations, effecting a great saving of time and insuring correct results. The rule itself is particularly well made, the blue lines on the white celluloid scales being pleasing to the eye and easily read. The best feature, however, is the accuracy of the rules, all of them being "engine divided," which adds greatly to the value of the instrument.

THE MOSSBERG MFG. CO., Attleboro, Mass., have issued a novel and substantial catalog, consisting of heavy binders board covers, which contains leaves describing their various manufactures, held by brass fasteners, enabling new circulars to be inserted from time to time. Among the many specialties are the anti-friction roller-bearing Mossberg patent lifter for drop presses, drop and broaching presses, milling machines, etc. Mr. Mossberg is well known in connection with advanced tools, and these specialties reflect his ingenuity.

NOTES ON MACHINE DESIGN: Charles H. Benjamin, M. E. 92 pages. $1.50. Charles H. Holmes, 2,313 Euclid Avenue, Cleveland, Ohio. No claim is made to originali y, the aim being to gather in a small compass the more simple formulas for the strength and stiffness of machine parts, with an explanation of principles involved. In this Prof. Benjamin has succeeded admirably, and the student who is acquainted with what to a shop man is higher mathematics, will find the book of great value, as the main elements of ordinary machine work are treated and examples given to work out. We think it better to give the correct solution of all such examples, as it enables a student to know when he has correctly solved a problem, and the one who will simply copy the answer will not attempt to solve it correctly if it is not given. There is a generous supply of blank leaves distributed among the problems for solutions, notes, etc., and we heartily commend it to all interested in machine design, which should include every young man in the mechanical trades.

HOW TO BECOME A SUCCESSFUL ELECTRICIAN: T. O'Connor Sloane. 189 pages $1.00. Norman W. Henley & Co., New York. This is similar in size and style to the other books by this author, and as with them he has given much useful information to the reader of the books. The advice it contains is valuable in any profession, for it deals with the necessary foundation to make a man successful in whatever he undertakes; not financially perhaps, but in the higher meaning of success, and the other generally follows after professional success is assured. Any one who is studying electricity at home will discover many useful hints in this book, and by following the lines suggested will find home study considerably easier.

THE new catalog of the Swift Lubricator Co., Elmira, N. Y.. shows a large variety of lubricators, oil cups, and other appliances, and the information on attaching lubricators ought to be valuable to engineers.

"BORING a square hole" has long been a standing joke in machine shops, but in their new catalog the Geometric Drill Co., New Haven, Conn., show how to bore and turn almost any shape that can be used in machinery. For such work it seems admirably adapted and not as complicated as might be expected.

BRASS PIPE PLUMBING is the title of a neat little book issued by the American Tube Works, 20 Gold street, New York, showing the advantages of brass over other pipes for household work, and giving many interesting testimonials from users of the pipe. Handy tables giving equivalent sizes of lead and brass pipes are also given.

THE Ohio Valley Industrial Review, which we mentioned last month, has changed its name to the National Industrial Review. Its price is now $1.00 per year.

THE proceedings of the National Convention of Manufacturers have been collected in pamphlet form, making preservation an easy matter. Many of the addresses are extremely interesting and instructive.

THE Cornell University Register has grown to a volume of 277 pages, and contains much of value to those interested in higher education, as well as the usual list of students.

UNDER the title of "LATHES—GOOD LATHES," The Lodge & Shipley Machine Machine Tool Co., of Cincinnati, Ohio, give in a concise form the main features of their new engine lathes. Among the good points, we note generous bearings, hollow spindle, micrometer index on screws, which enables accurate measurements without calipers, and an improved arrangement for throwing in change gears for screw cutting.

THE thirty-fifth edition of the catalog of Goulds Manufacturing Co., Seneca Falls, N. Y., is a substantially bound volume of over 350 pages, containing pumps and pump supplies for all services. The illustrations showing the application of these to their varied uses are all half-tones, and reflect credit on both designer and manufacturer. Pumps for every service are shown, including a line of electrically driven pumps of large and small powers. In addition, there are numerous tables giving capacity of pumps, friction of water in pipes, barometric pressure, etc. It will be furnished to manufacturers generally.

MAXIMS AND INSTRUCTIONS FOR THE BOILER ROOM: N. Hawkins, M. E., 311 pages $2.50. Theo. Audel & Co., New York. This is a book written for the fireman in a language that he can understand, and is liberally illustrated when illustration will aid in the explanation of a piece of machinery or an idea. It describes different types of boilers and their management, and contains useful rules, tables and other information which every fireman should learn. The book is well bound, and printed on heavy paper.

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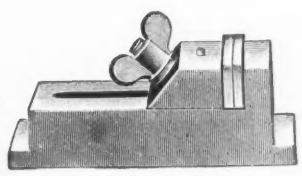

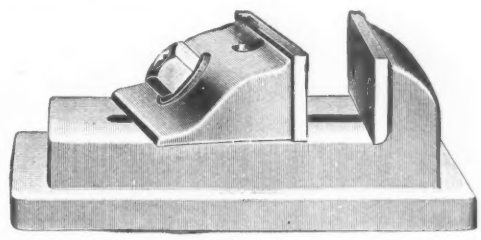

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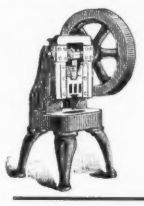

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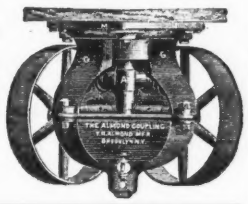

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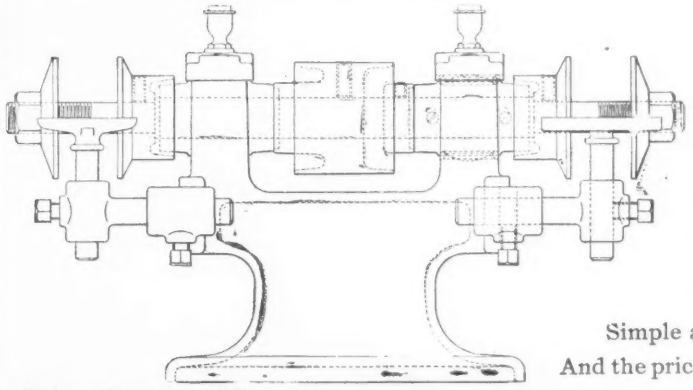

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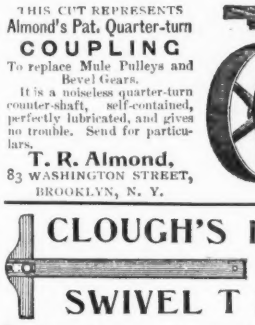

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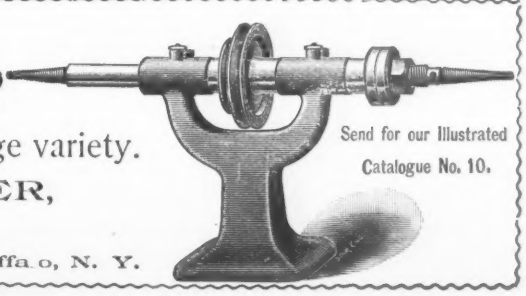

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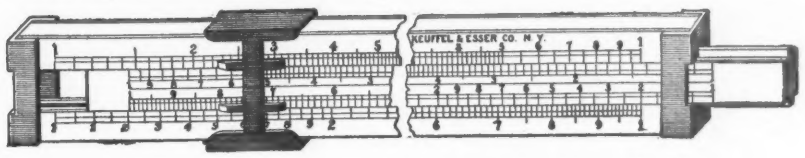

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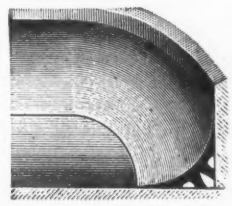

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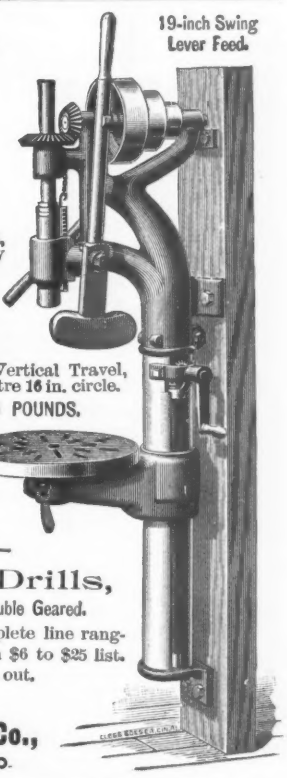

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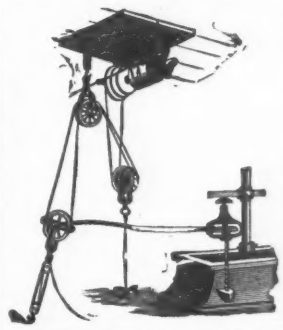

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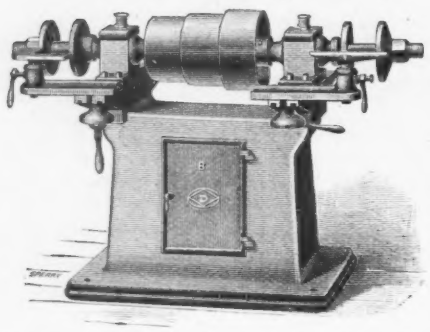

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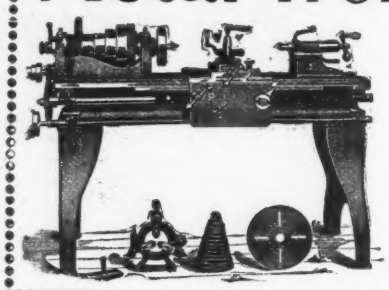

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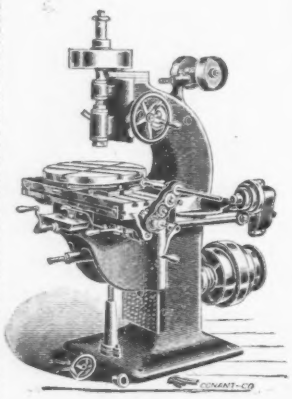

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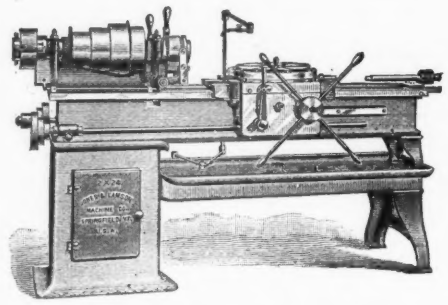

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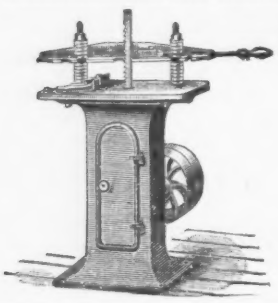

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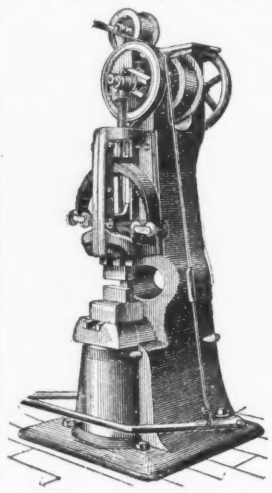

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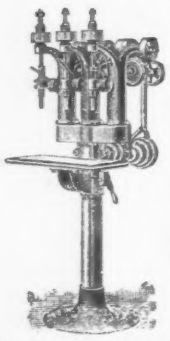

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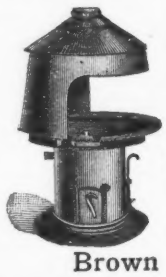

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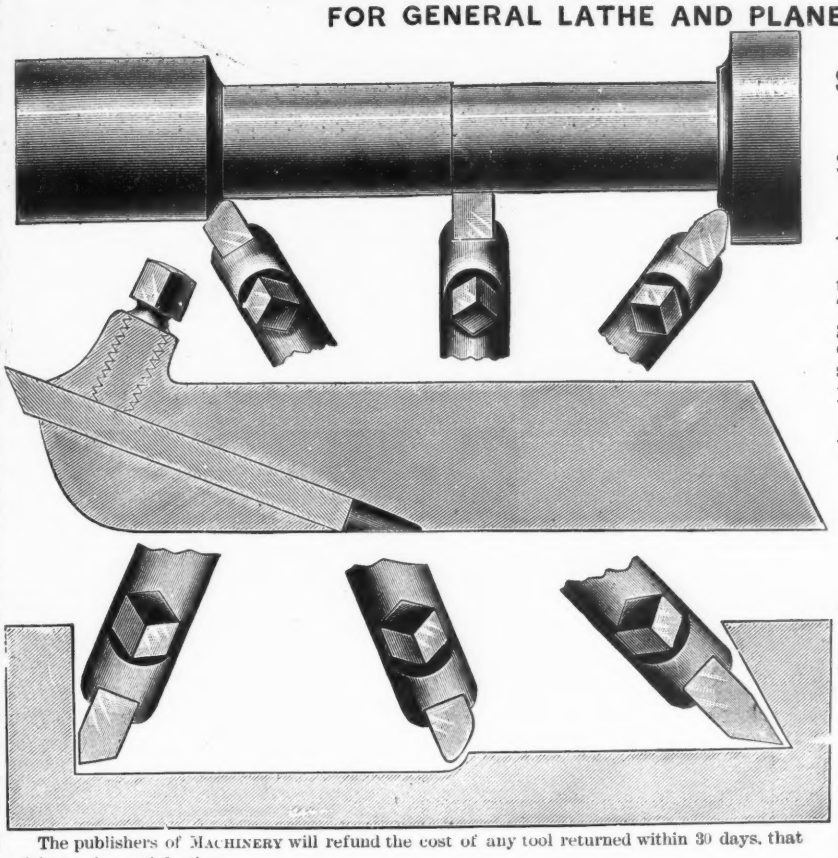

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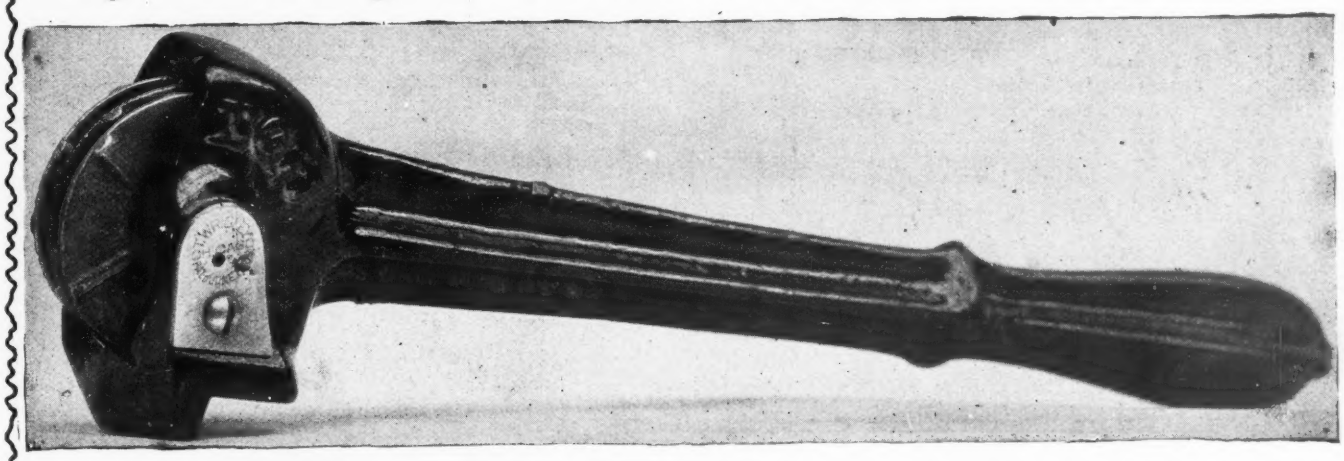

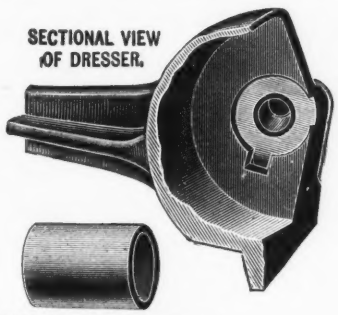

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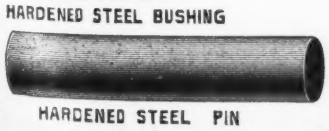
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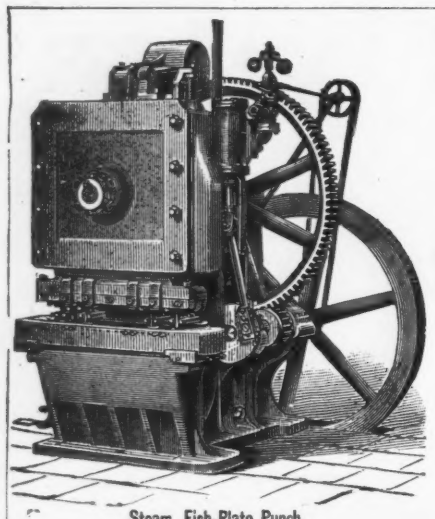

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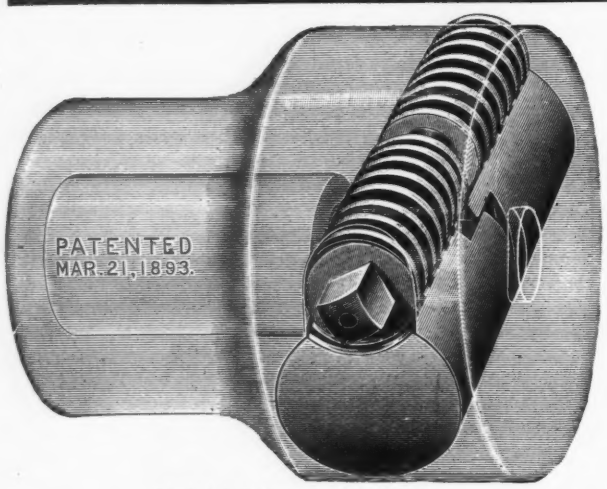

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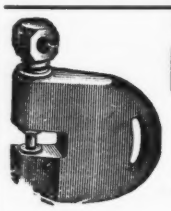

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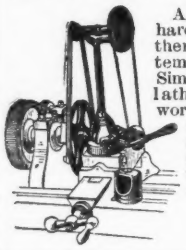

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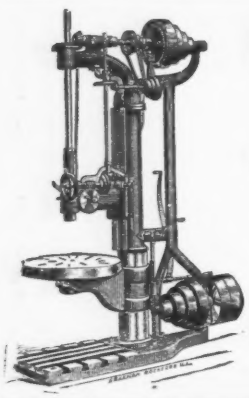

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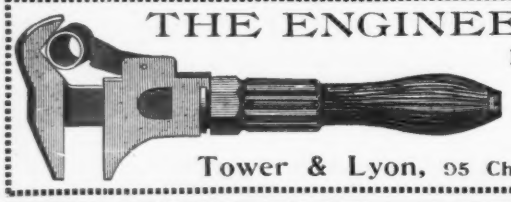

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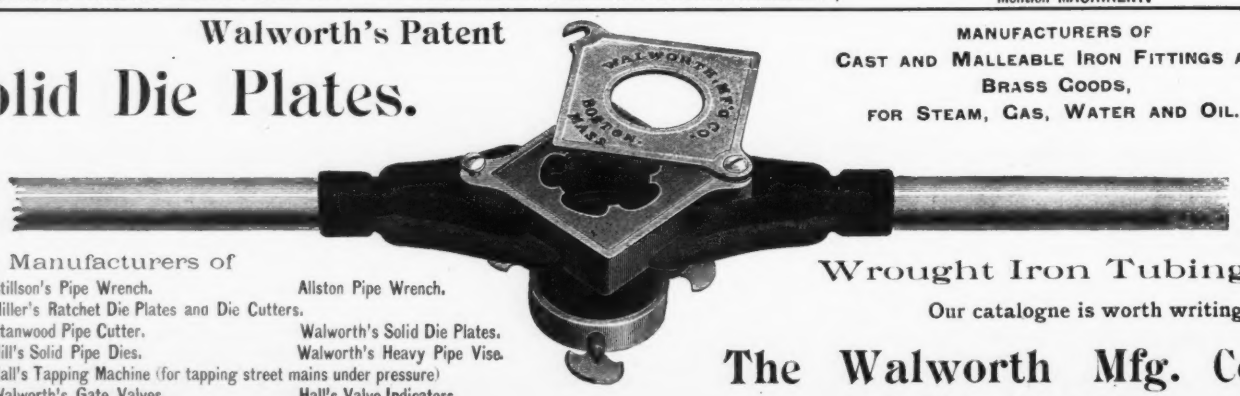

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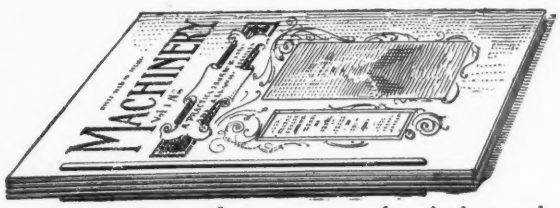

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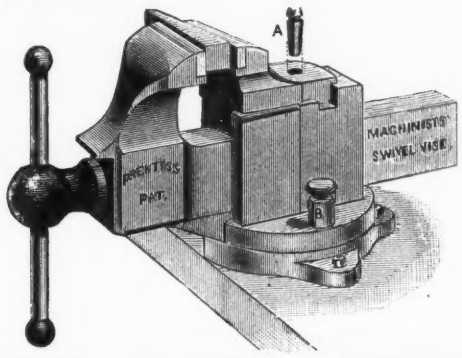

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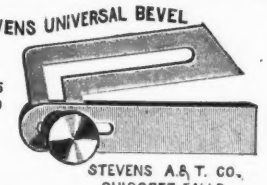

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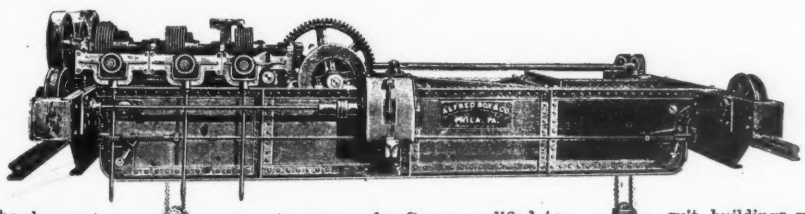

The above cut represents our regular Crane, modified to suit buildings where it has been necessary to keep the runway within three feet of the ceiling; the operator's cage being omitted. These machines are driven with single motor, and have all the usefulness of the more complicated and expensive three motor types; and are built from five to forty tons capacity and any length of bridge required.

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A new and useful tool for Pattern Makers and others to make round rods of wood for Pins or Dowels, etc. Can be used in connection with a power-turning lathe, held in the hand, or fastened in the tool post of a sliding-rest or carriage. - - - - - PRICE, $3.00.

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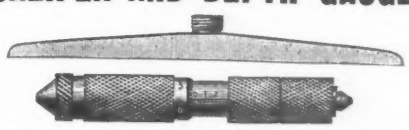

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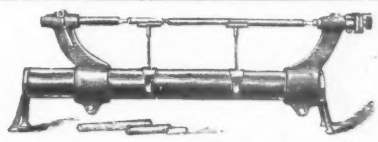

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The only Micrometer that will not lose its accuracy by wear.

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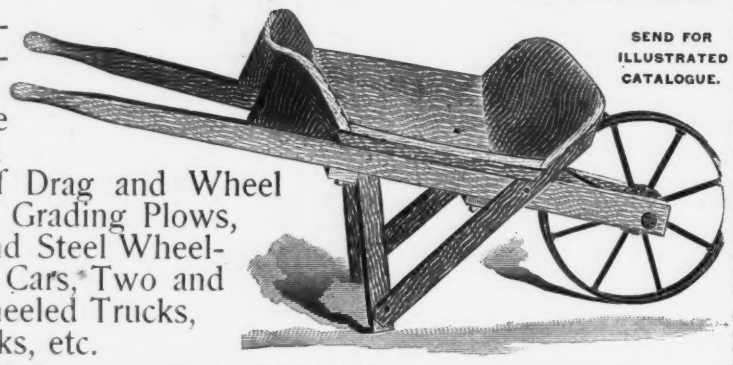

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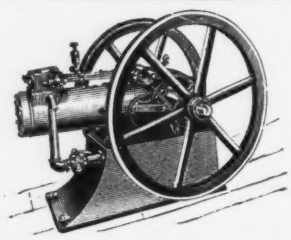

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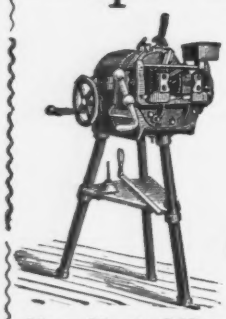

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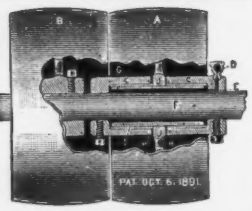

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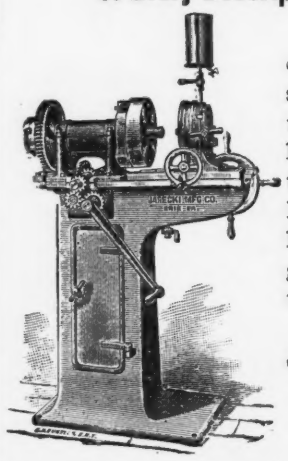

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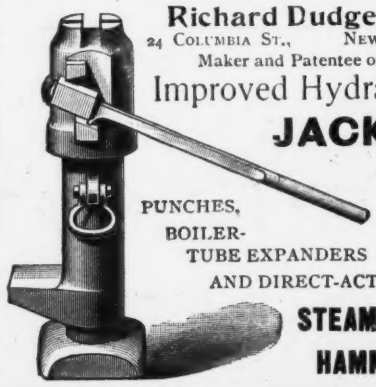

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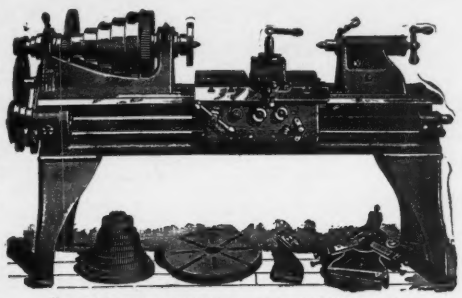

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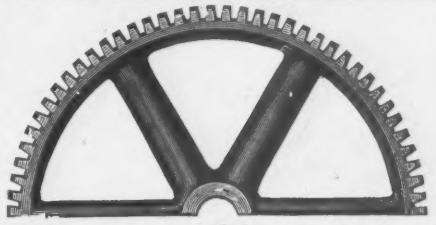

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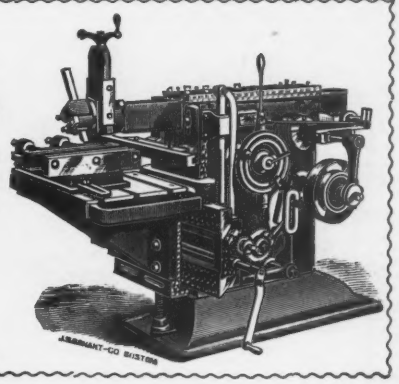

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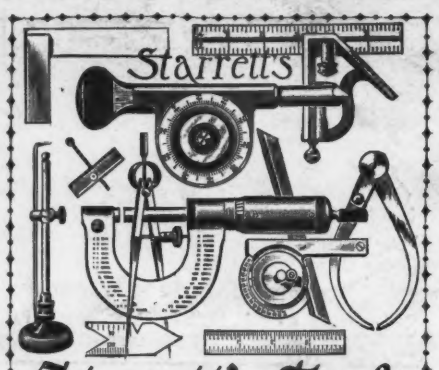

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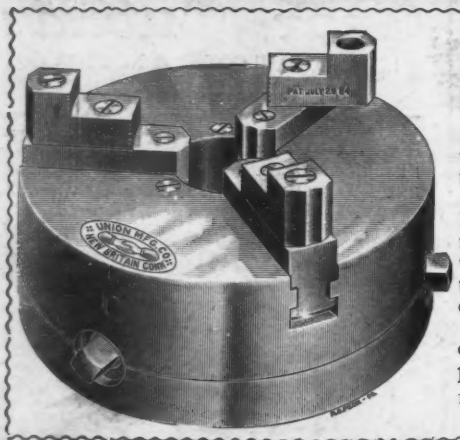

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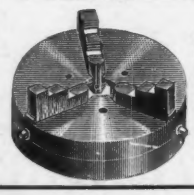

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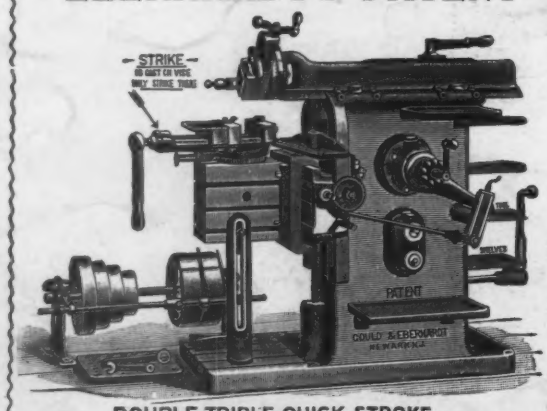

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